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SEQUENCE PERCEPTION, FINGER DIFFERENTIATION ABILITY,
AND READING ACHIEVEMENT IN ACHIEVING AND
NON-ACHIEVING READERS

by



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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance a thesis entitled "Sequence Perception, Finger Differentiation Ability, and Reading Achievement in Achieving and Non-Achieving Readers" submitted by Berenice Yvonne Chislett in partial fulfilment of the requirements for the degree of Master of Education.

ABSTRACT

This study was designed to ascertain the ability of achieving and non-achieving readers in Grade Two to perceive letter sequences in words, sequences in combinations of letter-like forms, and their finger differentiation ability. The relationships between these abilities were investigated as well as the relationship of each ability to three measures of reading achievement.

The two groups of subjects consisted of thirty students each, selected from two Edmonton Public Schools. They were selected on the basis of achievement or non-achievement in reading as measured by the Metropolitan Reading Achievement Test - Primary II; performance on the California Short-Form Test of Mental Maturity - Level I; and the results of a vision screening. These subjects were tested individually on their perception of letter sequences in words, their perception of sequences in letter-like forms, and their finger differentiation ability. All testing was completed by the researcher during May, 1970.

Correlations and an analysis of covariance were used to analyze the data which had been collected.

The analysis revealed that achieving readers made relatively few sequence errors either with letters or with letter-like forms. This showed no relationship to their reading achievement. Non-achieving readers made many more letter sequence errors. This had a low positive relationship

to their reading achievement reaching a level of significance with achievement in word discrimination. The non-achieving readers had a high correlation between their ability to perceive letter sequences and sequences in the letter-like forms. Their perception of sequence with these letter-like forms also had a low positive correlation with their reading achievement, reaching a level of significance in its correlation with reading comprehension.

A higher number of achieving than non-achieving readers passed the three finger differentiation tests. For both groups, the lowest numbers of passes were recorded on Test 2. A comparison of the tests revealed that significantly more students passed Test 3 than Test 2.

In this study, finger differentiation ability did not reveal any relationship to the perception of sequence using either letters or letter-like forms, to reading achievement, or to age for either achieving readers or non-achieving readers.

The theory that a relationship exists between finger differentiation ability and the spatiotemporal perception of sequence was not supported as it was investigated in this study, within the context of a reading situation.

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CHAPTER I

THE PROBLEM

INTRODUCTION

This study is an attempt to isolate one aspect of perceptual abilities--the perception of sequence--for an investigation of its significance in reading success at the grade two level. The perception of sequence is examined as both a visual perceptual ability and as an ability evidenced in the body schema through finger differentiation. An attempt is made to examine the possibility of a relationship between these two perceptions of sequence as they affect reading achievement.

BACKGROUND TO THE PROBLEM

The Problem in a Reading Context

Theories of the perceptual act involved in reading have usually drawn on the theories of perception which have been developed within the field of psychology. One of these, which had its greatest impact during the 1920's and 1930's and continued with varying strength beyond that time, is the theory of the Gestaltists. In reading, the influence of this school of thought led to the emphasis on the whole word as the unit of recognition. By this method, the teaching of reading was begun by presenting whole words

to children as the units of recognition rather than the individual letters comprising the word.

The whole word method of reading appears to form part of the reading performance of the literate adult (Vernon, 1962, p. 110). He is able to read without attending to the many details of words unless he encounters an unfamiliar context because he has developed an expectancy for certain letter sequences and an ability to utilize only a few letter details in word recognition. This reading performance, however, is quite different from a child's lack of concern for letter sequence for it represents a stage reached after the reader has had sufficient encounter with letter sequences as the printed representations of certain sound sequences to build up an expectancy for them.

The written word acquires its specific identity by reason of the sequential arrangement of its letters. If this arrangement is re-arranged or the order interrupted in any way, the specific identity of that word is lost. Thus the order or sequence of letters within words becomes an important characteristic of the word and permits a constant interpretation of meaning whenever the word is encountered.

In discussing the importance of the order of letters in words, Money (1962) has described the building of a reading vocabulary as a

. . . feat in building up an inventory of visual patterns all made up out of the same twenty-six alphabetic components and distinguished from one another by reason of the sequential arrangement of the components. The learner, must form a concept of each word as a symbol which retains a constant identity despite variations in position, size, colour, or script--shape, but which completely loses identity if fragmented and re-assembled in different sequential order (p. 24).

The Problem as One of Sequence

The child's perception of sequence as part of his total perceptual development, follows a developmental process (Vernon, 1962; Piaget, 1963). Vernon (1962, p. 91-93) says that the ability of the child to perform different visual perceptual tasks reaches a peak of development at different age levels, with some being performed accurately at six or seven but others at eight or later.

Piaget (1963) recognizes two aspects to this perceptual skill--the perception of order and the representation of order. He recognizes the perception of order as involving, "the perception of proximities, the separation of neighbouring elements, and a constant direction of travel in successive centrations upon these elements (p. 102)."

However, the child who has really acquired the concept of order is able to maintain a mental image of what has been perceived so as to reproduce it. While the five and six year old children that he studied could perceive and reproduce an ordered sequence without constant matching with a model, there was some trial and error

involved because their conceptual thought did not yet control their motor activity. He found that "toward the age of six or seven, children arrive at what may be considered a stable and rational conception of direct and reversed order. They eventually come to see the order between members of a series as part of a unified whole . . . (p. 101)."

The child of seven is usually in his second year of formal schooling. Even if there exists a lack of maturity in this aspect of his perceptual development, he must perceive and maintain a mental image of ordered sequences if he is to be successful in reading. Not only must he apply this concept of order, but he must now do so in the two-dimensional world of abstract symbols, the graphic representations of oral language. Piaget's conclusions were based on the child's performance with the three-dimensional objects of his concrete world. Is the child's application of this concept of order going to be more difficult in the symbolic world?

Vernon (1960) concluded that,

. . . the order of letters in words is a matter of indifference to young children, and that they have great difficulty in remembering the correct order, and hence in differentiating words containing the same, or almost the same, letters in a different order (p. 28).

This conclusion she based on an examination of research studies on the performance of five to nine year old children in their awareness of letter order. Elsewhere (1962) she says that "confusions over order of letters in

words are even more difficult to eradicate than confusions over letter shapes (p. 108)."

Ilg and Ames (1950, p. 309) found that the reversal of single letters or of the order of letters was very prominent in children aged five to seven years. They concluded that this was part of a normal stage of development for the children at this age level. To what extent does this confusion over letter order contribute to difficulty in reading? Is it one source of difficulty for non-achieving readers beyond this age level?

Finger Differentiation as Part of the Problem

Around the same time that the child's perception of sequence in the realm of printed symbols is of such importance to him, it appears that he is developing a perception of sequence in his development of his body schema. Kinsbourne and Warrington (1963) have identified a maturation of the child's sensory differentiation of the spatial arrangement of his fingers as evidence of this bodily perception of sequence. They conducted a study on a nursery school population of ninety children in London, England to identify this as part of the normal perceptual development of the young child. They found that 50 percent of the children, aged five to six years, could perform their tasks for finger differentiation, while 90 percent success was achieved by the children who were aged seven and one half years. Kinsbourne and Warrington felt that this ability to differentiate his fingers may well be related to

the acquisition of other abilities by the child. They believe it entirely possible that "at any stage, facility in the analysis of data derived from the external world is matched by comparable facility in the analysis of somaesthetic input (p. 136)."

They further suggest (Kinsbourne and Warrington, 1963, p. 136-137) that, when the child acquires this ability around the age of seven years, it is not specifically a differentiation of the fingers which he has acquired. Rather, they suggest, that what he has acquired is a perceptual ability which opens for the child a new means of processing sensory information. It may be that the child has acquired a spatial perceptual ability which can be used to differentiate sensory input both from within the person and from his external space.

Does this mean that the young child who has not successfully acquired this differentiation of the spatial arrangement of his fingers will encounter difficulty in his perception of spatiotemporal sequence in his environment?

PURPOSE OF STUDY

This study was concerned with one aspect of the child's environment where the perception of sequence is necessary, namely the reading situation. Within this context, the study centered on the investigation of two questions: These were:

- (1) Are difficulties in the perception of

letter sequence and the sequence of letter-like forms experienced by either achieving readers or non-achieving readers or by both?

(2) Are these same readers experiencing difficulties in the perception of sequence in their body schema as evidenced in their finger differentiation ability?

DEFINITION OF TERMS

Visual Perception

This is the process by which phenomena are apprehended by the mind through the medium of the eye (Goins, 1958).

Letter Sequence

This refers to the order of letters in a word such that the specific order must remain constant in order for the word to retain its identity and as determined by the examiner's Letter-Sequence-in-Words Test.

Letter-Like Forms

The twelve forms which were developed by Gibson, Gibson, Pick and Osser (1962), using the same constraints as imposed on actual letters, were arranged in sequences to correspond to three, four, five, or six-letter words. The perception of these sequences was measured by an examiner-constructed test entitled the Sequence Test of Letter-Like Forms.

Finger Differentiation

This is the ability to know through tactile perception the order or sequential arrangement of the fingers on both hands as determined by Kinsbourne and Warrington's Test of Finger Differentiation.

This test contains three separate subtests. By his performance on each of these, the subject fell into one of four categories on each subtest. These four categories were:

FM - The subject in this group correctly answered five or less of the eight items and moved their fingers on one or more of the remaining items to identify the spatial positions of these fingers.

PM - The subjects in this group correctly answered six or more of the eight items in a test and moved their fingers on one or both of the remaining items to identify the spatial positions of these fingers.

F - When the subject correctly answered less than six of the eight items in the subtest and did not move his fingers to identify their spatial positions, he was placed in the F-group.

P - When the subject correctly answered six or more of the eight items in the subtest and did not move his fingers to help him identify their spatial position, he was placed in the P-group.

Intelligence Quotients

The intelligence quotients derived from the scores obtained on the California Short Form Test of Mental Maturity - Level 1 - was the measure of intelligence used in this study.

Reading Achievement

The percentile rankings obtained on word knowledge, word discrimination, and reading comprehension as measured by the Metropolitan Reading Achievement Test - Primary II, were accepted as measures of reading achievement. These three subtests will hereafter be referred to as the tests entitled Word Knowledge, Word Discrimination, and Reading Comprehension.

Achieving Readers

These were the thirty readers, seven to nine years old, within the 90-120 range of intelligence, who placed at or above the seventy-fifth percentile on any two of the three subtests of the Metropolitan Reading Achievement Test - Primary II.

Non-Achieving Readers

These were the thirty readers, seven to nine years old, within the 90-120 range of intelligence, who placed at or below the forty-fifth percentile on any two of the three subtests of the Metropolitan Reading Achievement Test - Primary II.

HYPOTHESES

The following hypotheses were formulated for testing in this study:

(1) There is no significant correlation between the ability to perceive letter sequences and reading achievement in grade two children, seven to nine years old, when the effects of intelligence are removed, for

(a) achieving readers

(b) non-achieving readers

(2) There is no significant correlation between the ability to perceive sequence in letter-like forms and reading achievement in grade two children, seven to nine years old, when the effects of intelligence are removed, for

(a) achieving readers

(b) non-achieving readers

(3) There is no significant correlation between the ability to perceive letter sequences in words and the ability to perceive sequence in letter-like forms, when the effects of intelligence are removed, for

(a) achieving readers

(b) non-achieving readers

(4) Within each of these groups of readers, there is no significant difference among the finger differentiation groups, controlling for intelligence, on

(a) Reading Test 1 - Word Knowledge

(b) Reading Test 2 - Word Discrimination

(c) Reading Test 3 - Reading Comprehension

- (d) Letter-Sequence-in-Words Test
- (e) Sequence Test of Letter-Like Forms
- (f) Age

DESIGN OF THE STUDY

Sample

The sample used in this study consisted of sixty grade two children, seven to nine years old, selected from two mid socio-economic schools in the Edmonton Public School System.

Procedure

(1) To a test population of 118 children, the researcher administered the California Short Form Test of Maturity - Level 1. Of the children tested, 108 fell within the 90-120 range of intelligence.

(2) These 108 children were given the Metropolitan Reading Achievement Test - Primary II.

(3) The subjects to be used in this study were then selected from this test population on the basis of their performance on this reading test. Those subjects who placed at or above the seventy-fifth percentile on any two of the subtests were selected as achieving readers. Those subjects who placed at or below the forty-fifth percentile on any two of the subtests were selected as non-achieving readers.

(4) Each of these children were then seen individually by the examiner when the following tests were

administered:

(a) an eye-screening on the Keystone Telebinocular. Any subjects with serious visual defects were then eliminated from the study.

(b) a test of the subject's perception of letter sequences in words as constructed by the researcher.

(c) Kinsbourne and Warrington's Test of Finger Differentiation.

(d) a test of the subject's perception of sequences in letter-like forms which were grouped to resemble words. This was also a test constructed by the researcher.

The administration of the Letter-Sequence-in-Words Test and the Sequence Test of Letter-Like Forms was interchanged in a random manner so as to randomize the effects of practice or any tiring effects which might influence the student's performance. The researcher realizes that the decision to not have these two tests follow each other at any time placed the Test of Finger Differentiation in a constant middle position. It is thus possible that the order of this test may have had some effect on performance on it and the other tests.

All testing was conducted by the researcher during May, 1970. The data was analyzed at the Department of Educational Research, University of Alberta and interpreted by the researcher.

LIMITATIONS OF THE STUDY

(1) The researcher realizes that the test of finger differentiation which has been constructed by Kinsbourne and Warrington has been validated only on the sample of ninety nursery school children in London, England. However, it does closely parallel the test of finger agnosia commonly used in neurology to measure the loss of an awareness of the spatial position of the fingers.

(2) The researcher is concerned with the spatio-temporal perception of sequence in achieving and non-achieving readers who have been determined as such for this study. Had the population from which the researcher could draw the sample been larger, more precise criteria might have been used to determine achievement or non-achievement in reading. Under those conditions, results might vary considerably from those obtained in this study.

(3) This study is not concerned with establishing a developmental pattern for either finger differentiation or the perception of letter sequence but rather a study of these two factors in a particular group of children, seven to nine years old.

SIGNIFICANCE OF THIS STUDY

Several claims have been made for the young child's lack of concern for letter sequence. This study will indicate whether, in this group of readers, such a claim is

warranted. It will also determine whether this is significantly related to the reading achievement of the children used in this study. If a relationship exists, the classroom teacher may have available another factor which he can use in assessing the learning needs of the young reader. If difficulties in the perception of letter sequence are significantly related to reading achievement, further studies can explore the possibility of improving the child's word recognition ability by improving his perception of letter sequence.

Kinsbourne and Warrington (1963) indicated that what the child had gained when he had acquired finger differentiation ability was an ability which applied to a wide range of tasks in external space. If this study discovers a strong relationship between finger differentiation ability and the perception of letter sequence, this theory will be supported. Out of this an important issue arises for further study. Must the perception of sequence in the body schema precede perception of sequence on the printed page? Will training in the perception of letter sequence be effective if the perception of sequence in the body schema is not present?

SUMMARY

This chapter has provided an overview of the research which was undertaken. The nature of the problem was discussed and the problem presented. To investigate

this problem, four null hypotheses were formulated. A research design was then developed so that the data necessary for testing these hypotheses could be collected and analyzed. Within the design, the sample, the test instruments, and the testing procedures were outlined. In concluding the chapter, the limitations of the study were acknowledged and the possible significance of it was outlined.

CHAPTER II

REVIEW OF SELECTED RESEARCH

INTRODUCTION

The research findings to be reviewed in this chapter will be presented in three separate sections. The first section investigates the relationship of visual perceptual abilities to reading achievement and the role of these abilities in reading process. It does not attempt to review all of the research which has been done in the field of visual perception and reading. Rather, it contains a selection of studies, so selected as to be representative of the total research. In this way, the researcher has been able to present more fully what these studies revealed.

In the second section, the aspect of visual perception with which this study is concerned--the spatial perception of sequence--has been isolated. This section contains a review of selected research on the development of this ability and its relationship to reading achievement.

In the final section of this chapter, the second perceptual ability with which this study is concerned--the bodily perception of sequence as evidenced through finger differentiation--is isolated for a review of the research which has been done on the nature of this ability.

THE RELATIONSHIP OF VISUAL PERCEPTUAL ABILITIES TO READING ACHIEVEMENT

Introduction

In order to read the child must perceive the similarities and differences of the printed symbols. To Smith and Dechant (1961, p. 23) what is signified by these symbols is more crucial in reading than what is seen. They conclude that "without perception there is no true meaning. It is through perception that the graphic symbols achieve meaning (p. 28)." Much research has been centered on actually investigating the role of this perceptual process in reading. Within visual perception, research has been concerned with its actual significance to reading at various levels of development; the different visual perceptual abilities involved in reading; as well as the best means of measuring these abilities.

Research on this Relationship

An early study by Gates (1926) in this field revealed that visual perception does play a significant role in reading. He gave his constructed tests of visual perception to a representative sample of 310 pupils from Grades One to Six. Using three different kinds of test items--geometrical figures, digits, and words--he found that word perception correlated relatively highly with reading when the effects of intelligence were removed. Perception tests using geometrical figures and digits appeared to exert little influence on reading. In his

study, the word perception factor which he isolated, whether the effects of intelligence were removed or not, was more highly correlated with reading than intelligence.

In a later study, Gates (1940) investigated the predictive value of a series of seven reading readiness tests for predicting reading achievement. Two of the tests in this battery were word perception tests. These had a correlation of .45 and .47 with the reading achievement of 173 grade one children at the end of their first term as measured by the Gates Primary Reading Test. These two measures of word perception yielded higher correlations with reading achievement than the other five reading readiness factors studied.

Gates compared these results with those he obtained in a previous study where correlations of .58 and .55 were obtained between very similar tests and reading achievement. He concluded that the predictive value of the tests varied from class to class and was somewhat dependent on the instruction given and pupil characteristics.

An early study on letter-matching ability as it relates to reading achievement was carried out by Smith (1928). She had first grade teachers give a letter-matching test to beginning readers representing average, below average, and superior children. This was during their first week of school. Twelve weeks later they were tested for reading ability on the Detroit Word Recognition Test. A correlation of .87 pointed to a strong relationship

between letter-matching ability and reading achievement. She also measured the word-matching ability of these subjects in the middle of Grade One on nine nonsense three-letter words. Results were analyzed according to the percentage of errors occurring when a hard or easy consonant began or ended the syllable. These had been identified in the letter-matching test. All percentages of errors were between 15-20 percent and no correlation with reading ability was computed.

Petty (1939) investigated the effects of five different factors on reading readiness. One of these factors was the ability to perceive the written symbols used in reading. This was measured by a condensed form of the Lee-Clark Reading Readiness Test. This two-part test required the matching of letters printed on a page and the crossing-out of superfluous letters in the second word of a pair to make it an identical pair. Using 122 subjects in low first grade, she found that the ability to deal with letter symbols is necessary in beginning reading. The time taken to do the test had a correlation of .44, significant at the .05 level, with reading, while the scores obtained on the test had a correlation of .40, significant at the .06 level, with reading.

All of these early studies thus agree that the ability to perceive letters and words has a significant relationship with reading achievement for beginning readers.

A recent study by Shea (1968) confirmed this

finding. She constructed and validated her own test on the visual discrimination of words. Seventy-six beginning grade one children were tested on her visual discrimination test, the Metropolitan Reading Readiness Test, and the Lorge-Thorndike Intelligence Test. In January, they were given a Word Recognition Test. Both visual discrimination and intelligence were found to have equally significant correlations of .65 and .66 with word recognition ability. The Metropolitan Reading Readiness Test had a similar correlation of .61 with word recognition. From these results the researcher concluded that an optimum combination for predicting first grade word recognition would be the Word Discrimination Test and either the Lorge-Thorndike Intelligence Test or the Metropolitan Reading Readiness Test. Word recognition, however, is only part of the performance which must be considered in discussing reading ability. This study is thus limited to one aspect of the reading process.

A study by Harrington and Durrell (1955) was centered on whether mental maturity or perceptual abilities are more important in primary reading. They used an oral reading test and a silent reading word classification test to measure the reading achievement of 500 primary children. These tests were mainly a measure of the child's reading vocabulary. Mental maturity was measured by the Otis Quick Scoring Test. To measure his visual discrimination, the child was asked to choose, from a multiple-choice situation,

the word he had just seen on a flash card. The researchers found a significant correlation between visual discrimination and reading but not between mental age and reading.

The word discrimination test used by Shea and that used by Harrington and Durrell both included a memory factor. It is possible that this variable had an effect on the results obtained in both of these studies.

The possibility that retardation in the development of perceptual ability might be a factor determining success in reading for reading disability cases was the subject of a study by Coleman (1953). The forty reading disability cases he used were of average or better intelligence and had no emotional or physical handicaps. Thirty-three of the subjects were under the age of thirteen. To measure their perceptual development, he used the Alpha-Test of the Otis-Quick Scoring Intelligence Test. While sections of this test require higher-order abstraction, he claimed that it did rely heavily on perceptual factors. The mental age obtained was regarded as the perceptual age of the subjects and was subtracted from their chronological ages to give an index of retardation. He also computed a perceptual-intellective lag index by subtracting the Otis Quick Scoring Intelligence Test mental age from the mental age obtained from the Stanford-Binet Scale or the Weschler Intelligence Scale for Children to show that their performance was not the result of low intelligence.

For the group of thirty-three children, he found a

mean retardation of almost a year in perceptual development. These results were significant at the .01 level. However, six of the subjects were average or above in their perceptual development. He found perceptual retardation to be cumulative in children and a significant factor in their reading disability. The perceptual-intellective lag index showed perceptual development to lag significantly behind the development of general intelligence.

Another study of visual perception as a factor in reading disability was carried out in Sweden by Malmquist (1958). He used a national sample of 365 children in his study. The five visual perception tests which he constructed for use had matching-type exercises. This battery included tests with figures, letters, digits, geometric configurations, and nonsense configurations. The correlations of the visual perception tests using letters, digits, and figures with reading achievement were low but significant at the .01 level.

This study found that the ability to discriminate letters and digits was more significant in first-grade reading than the ability to discriminate figures, geometric configurations, or nonsense configurations.

A detailed study of the relationship of the visual perceptual abilities of first graders to their reading achievement was carried out by Goins (1958). She wanted to measure the level of competence of first-graders in visual perceptual abilities and to determine the predictive value

of her tests of visual perception for early reading achievement. Her test battery consisted of fourteen non-verbal measures of visual perception and two Chicago Reading Tests. Goins felt that using visual perception tests with letters or words would only result in separating the readers and non-readers.

Correlating the results of each of the perceptual tests from 120 children with their results on the reading tests, she obtained these correlations, significant at the .01 level, with the May reading test;

Perceptual Test	Correlation with May Reading Test
Pattern Copying	.591
Reversals	.491
Figures	.390
Picture Squares	.381
Pattern Completion	.339
Cancellation	.302
Combined measures of visual perception	.497

The Reversals and Pattern Copying tests had the highest correlations with the reading test and a correlation with each other of .642. This was the highest correlation of any two perceptual tests. Goins identified both of these, as well as Pattern Completion and Figures, as measuring the factor called "strength of closure". This ability enables one to hold a figure in mind against a

distracting field or background. Based on this research, it appears that an important factor in reading is the ability to hold in mind the "wholeness" of a word, phrase, or sentence while attending to individual parts of it (p. 104).

However, here the researcher had to apply to the world of written symbols what had been found when she used non-verbal symbols such as pictures or geometric designs. What actually happens when a child encounters the printed symbols of the English language had not really been examined here.

Four of the visual perceptual tests which gave significant correlations in Goins' study--Pattern Copying, Cancellation, Reversals, Picture Squares--were used in a study of one hundred first-grade children by Seigler (1960). These tests were given at the beginning of the year and the scores were correlated with those obtained on the Gates Primary Reading Test given in February and the Gates Advanced Primary Reading Test given in May. All of the May correlations, significant at the .02 level, were a little higher than those obtained by Goins in May.

Partialling out the effects of mental age, a correlation of .61 was obtained between the combined measures of visual perception and reading achievement.

The similarity between the results obtained by both Goins and Seigler strengthens the conclusion that the specific visual perceptual abilities measured by these

tests--strength of closure and speed of perception--are important in the reading achievement of first grade children.

Positive but low correlations of both form and symbol discrimination with reading ability were found in a study by Wheatley (1965). She constructed twelve visual discrimination tests to administer to 102 first grade children. These were administered at the beginning of the first-grade and the results were correlated with reading scores obtained at the end of Grade One. To measure reading ability she used the three measures provided by the Gates Primary Reading Test and the six measures provided by the Survey of Primary Reading Development.

Both form and symbol reversals produced the highest correlations with reading achievement. The highest correlations were:

Reading Test	Correlation with Symbol Reversal	Correlation with Form Reversal
Gates Word Recognition	.38	.36
Gates Paragraph Recognition	.39	.29
Gates Sentence Recognition	.32	.29
Sentence Comprehension	.45	.34

Among the visual discrimination tests, the ability to perceive reversals in words produced the highest correlations with reading ability. However, the correlation of mental age with reading ability was found to be slightly

higher than the correlation between visual discrimination and reading ability.

Three of the measures of visual perception from Goins' study--Pattern Copying, Picture Squares, and Reversals--as well as four of Gates' tests used in his 1940 study were used to measure visual perception by Barrett (1965). He found that an optimum combination of visual discrimination tasks for predicting first grade reading achievement would be Gates' Reading Letters and Numbers, Goins' Pattern Copying, and Gates' Word Matching. The correlation of each of these with reading achievement was significant at the .05 level. Goins' Reversals Test also correlated at the .05 level with reading achievement. Except in one instance, Barrett found symbol discrimination tasks to be more significantly correlated with reading achievement than form discrimination.

The question of which types of visual perceptual abilities--alphabetic, digital and geometric, or pictorial--would correlate most highly with reading achievement in the primary grades was studied by Ashlock (1963). He proposed that these would arrange themselves in a hierarchy as listed. In testing, however, the proposed hierarchy was not maintained. While the alphabetic tests of visual perception showed the highest correlations with reading achievement and in the expected high positive direction, the geometric and digital tests gave lower correlations than the pictorial whose correlations were also low.

However, the memory test from the geometric section and the test of visual attention span from the pictorial section showed high, positive correlations with reading achievement. It would appear that memory and visual attention are important factors in primary reading achievement.

Five of Ashlock's tests of visual perception were sections from the Weschler Intelligence Scale for Children, two were tests of memory, some required manual reproductions, and others had a time limit on exposure. The influence of factors other than visual perception may thus have covered what significance a study of this nature might contain.

Studies of visual perceptual abilities as a factor in reading achievement beyond the first grade reveal that the significance of this relationship at upper grade levels may be underestimated. A study by Justison (1961) of third-graders' visual perception of form and school achievement lends support to this idea. He found a positive, significant correlation between the third-graders' copying ability as a measure of his form perception and a standardized test of reading achievement. His findings also give evidence of the role of visual form perception in school achievement.

A study by Weathers (1966) was concerned with the visual perceptual development of fifth-grade adequate and inadequate readers. For this study, inadequate readers were two or more years retarded in reading while adequate

readers read at or above grade level. Weathers used the Marianne Frostig Test of Visual Perception to measure the perceptual development of the thirty-one adequate and thirty-one inadequate readers. Significant differences, at the .05 level, resulted between the two groups on only two of the tests - Eye-Motor Co-ordination and Figure-Ground Discrimination. While male subjects demonstrated the same perceptual pattern as the total sample, the female inadequate readers also had a deficiency in Spatial Positions.

A detailed study of the visual perceptual abilities of fourth-grade children was carried out by Chirhart (1966). She was specifically interested in the relationship of their visual perceptual abilities to their word recognition skills. Chirhart tested 379 boys and 328 girls on nine perceptual tests and the seven word recognition subtests of the Silent Reading Diagnostic Test. Separate correlations were computed for the boys and girls.

The analysis of results showed the perceptual tests of Pattern Completion and Pattern Synthesis to have the highest correlations with the word recognition tests for both boys and girls.

Pattern Completion had a correlation at the .01 level of significance with all seven word recognition tests. The highest correlations were:

<u>Word Recognition Test</u>	<u>Boys</u>	<u>Girls</u>
Visual Analysis	.444	.404
Phonetic Knowledge	.425	.413

Pattern Synthesis had a correlation at the .01 level of significance with five of the seven word recognition tests for both boys and girls.

Generally, the correlations between visual perceptual abilities and word recognition skills were higher for the girls than the boys.

Chirhart also grouped her subjects on the basis of their achievement in the word recognition tests. This gave three groups of achievers - high, medium, and low. Examining her data, she found that those low in word recognition ability were characterized by low mean perceptual scores, while those high in word recognition ability were characterized by the highest mean scores in perceptual abilities.

From this research, it would appear that the students' visual perceptual abilities which involve analysis and synthesis are related to his word recognition performance where he is required to visually analyze words and apply phonic principles.

Results like these lend support to the theoretical construct of perception in reading disability offered by Birch (1962). He suggests that there are three levels of perceptual development - perceptual discrimination, perceptual analysis, and perceptual synthesis. While the child is capable of perceptual discrimination in his early years, perceptual analysis and synthesis come much later. He hypothesizes that one of the factors in reading disability is inadequate development of these two higher

functions, which are complex and more easily interfered with than discrimination. He suggests that some children with reading disability may have defective analytic and synthetic visual perceptual abilities. Chirhart's study does indicate a relationship between perceptual analysis and synthesis and word recognition skills.

Summary

From the research reviewed here, it can be concluded that visual perceptual abilities are significantly related to reading achievement both at the beginning levels and as the child progresses through elementary school. Some abilities--pattern completion or copying, reversals, word and letter matching, and pattern synthesis--were the perceptual abilities studied which gave the highest correlations. Those studies which used both the written symbols--letters or words--and forms generally found that those tests involving the written symbols correlated more highly with reading achievement than tests using geometric forms and configurations. Most of the studies presented have, however, examined visual perception as the sum total of several abilities. Few of them have attempted, as this study will, to isolate one specific aspect of visual perception for investigation.

RESEARCH ON THE PERCEPTION OF SEQUENCE AND ITS RELATION TO READING ACHIEVEMENT

Introduction

When the child is decoding the written symbols of the English language, he must perceive them in a particular sequence with a left-to-right orientation. The spatial position of these two-dimensional symbols form part of the distinguishing characteristic of the word.

Incorrect perception of the sequence of letters in a word can completely change the meaning or conceptual component of the word as in except for expect or render it meaningless as in rowd for word. Money (1962) says that "the constancy of sequential arrangement of letters one after another is the sine qua non of a word's identity (p. 24)."

The Development of the Perception of Sequence

During the course of development of the perceptual functions in the young child, there occurs a development in his perception of sequence. According to the work of Piaget (1963), this occurs around the age of five or six, but does not become a stable, operational concept until the age of six or seven with its development being facilitated by motor activity.

In their study of the young child's perception of sequence, Pufall and Furth (1966) support these age levels given by Piaget as well as his conclusions on the importance of motor activity in the development of sequential

awareness. They studied the recognition of visual sequences and the learning of visual sequences by children who were aged four, five and six years. To test the visual recognition of three-unit sequences of twenty children at these age levels, they used five matching tasks in which the child either reproduced the sequence or said whether two sequences were the same or different.

A developmental performance was noted from age four to age six. Although at all age levels significantly more errors resulted on tasks requiring a reproduction or verbal response after the stimulus sequence was removed, the subjects performed better when they could reproduce from memory than when they gave a verbal response from memory. Significant differences also occurred according to the type of material used with the greater number of errors occurring with two-dimensional materials. The researchers accepted that the motor activity provided by the three-dimensional materials and in matching by reproduction had an effect on these results.

In a second study with thirty-six children at these same age levels, they investigated the learning of visual sequences by children. They used two types of sequence-learning tasks - a simultaneous presentation of the sequence units and a successive presentation of the sequence units.

The results showed a developmental increase in the learning of visual sequences from age four to age six.

With the simultaneous presentation, 66 2/3 percent of the four-year-olds were successful while all the six-year-olds succeeded in learning to discriminate four sequences. With the successive presentation, none of the four-year-olds were successful in learning to discriminate the four sequences while 66 2/3 percent of the six-year-olds were.

Pufall and Furth suggest that with the simultaneous presentation the child did not have to internally represent the sequence but with the successive presentation this was necessary. Piaget had found that, working with concrete materials, it was not before the age of six or seven that the child could do this.

That the child's spatial perception develops from a random process to a stable and ordered one was the conclusion reached by Gottschalk, Bryden and Rabinovitch (1964). They used the responses of preschoolers to a pictorial display to study the spatial organization they used. Their conclusion was that the development of an awareness of order occurs through maturational and experiential factors rather than specific training and becomes very important for learning to read.

Similar conclusions on the role of maturation in the development of a systematic and ordered perception of stimuli were reached by Elkind and Weiss (1967).

Sequence Perception and Reading Achievement

Because the awareness of order or sequence appears to be an ability developed in the child as he matures, and because order and sequence are important spatial dimensions on the printed page, some research in reading has been concerned with the relationship between the child's ability to perceive sequences and his reading achievement.

One recent study in this area was done by Netzer (1969). She examined the difference between the ability of good and poor readers to discriminate spatial position while controlling for figure discrimination and memory. Using thirty good readers and thirty poor readers, she hypothesized that those who were experiencing reading difficulties would have difficulty in correctly perceiving a sequence pattern.

To eliminate the cognitive variable involved in using alphabetic symbols and to avoid the debated value of using geometric forms to predict reading achievement, she chose to use the twelve letter-like forms which were developed and validated by Gibson, Gibson, Pick, and Osser (1962). These were used in combinations of three's with the subject being required to match one of four sequences with the stimulus one after it was removed.

Her findings supported her hypothesis. The good readers scored significantly higher than the poor readers on the task of sequence discrimination. As a control for the possible influence of memory, subjects were tested for

sequence discrimination under conditions of repeated exposure of a model stimulus. This task was found not to effect the differences in mean scores between the two groups.

A correlation of .55 between the sequence discrimination task and reading achievement was significant at the .01 level. Partialling out the effects of intelligence, the degree of association remained significant at the .01 level with a correlation of .61 .

These findings suggest that "part of the difficulty in learning to read is related to the process of identifying sequences of letters as word units (p. 7)." An analysis of the results on the sequence test revealed that poor readers tended to show a much wider range of performance than good readers.

Sterritt, Martin and Rudnick (1969) also studied the child's accuracy in perceiving sequential patterns as it related to his reading achievement. They isolated six separate types of auditory and visual sequences which they recognized as being crucial in reading. Visual-spatial perception of sequence with no transference to another sense modality between stimulus and answer was considered one of the three easiest tasks. To test sequence perception here they used a sequence of dots with long and short spaces between. The child had to identify whether or not a second pattern was identical to the first after the first one was removed.

They tested forty grade-three children at the end of Grade Three and again in Grade Four.

An analysis of the relationship between the sequence perception tests and the battery of achievement and ability tests given generally showed low correlations. The highest correlations were obtained with phonics analysis scores when similar perceptual tests were combined. Here a correlation of .33 was obtained on the first set of scores and a correlation of .49 on the scores from the second testing period.

For most of the sequence perception tests, memory was found to be a controlling variable. It appeared that the difficulty level of the sequence perception tests was primarily determined by the stimulus modality used first. This was the one which had to be carried in the memory while the second one was being presented. As the stimulus modality used first, they found visual spatial patterns, with a mean of 2.43 errors, to be easier than auditory-temporal or visual-temporal which had a mean of 5.35 errors.

In a study by Kennedy (1954) of the types and frequency of reversal errors made by a group of normal children in Kindergarten, Grade One and Grade Two, letter transpositions was introduced as one of the four categories of reversal errors. Thus in Parts II and III of her test, one section consisted of words in which one of eight possible letter transpositions were introduced. From a choice of six alternates, the child chose the one to match

the stimulus which was a word in Part II and a picture of the word in Part III.

In Part II of the test there was a consistent and rapid increase in the number of correct responses from a low of 38.4 percent in Kindergarten to a high of 93.0 percent in Grade Two. Part III of the test was only given to grade one and two children and showed an increase in correct responses from 24.7 percent to 53.8 percent.

A comparison of the percentage of incorrect choices falling into each of the four reversal categories revealed that letter transpositions had the second highest percentage of errors in both parts of the test. Each of the eight types of letter transpositions were then examined for their frequency of occurrence. This revealed that the highest percentage of errors on both parts of the test occurred with internal to internal letter transpositions and terminal to internal transpositions with an increase in the percentage of errors in these categories from Grade One to Two on Part III of the test.

The researcher concluded that, while the type of reversal errors studied were normal in the earlier grades, they tended to disappear rapidly as the child progressed through the grades. There is, however, a greater tendency for letter transposition errors involving internal and terminal letters to persist than other reversal errors.

The results of this study correlate with the work of Marchbanks and Levin (1965). Using both kindergarten

and grade one children, they found that the first letter was the cue used most often in word recognition with both short and long words for readers and non-readers. The last letter was the second most important cue except for first-grade girls who used the second letter more often.

According to Kennedy, there is a rapid disappearance in the early grades of any tendency to transpose letters where the initial letter is concerned. The greatest number of errors occurred in the internal letter transpositions - that part of the word which Marchbanks and Levin found kindergarten and grade one children to use least often.

Hill (1936) had also found that beginning readers and normal readers in the primary grades use the beginnings and ends of words most frequently and as cues to word recognition. The middles of words she found to be least carefully observed and gave rise to the most errors. In one of the tests which she used in her study of word discrimination, she introduced a section where the letter items and configuration were kept constant while changes were made only in the order of letters. There was only one change introduced in each of the six choices offered the subject. She found that the percentage of errors made by her subjects was relatively high, accounting for 41.86 percent of the total possible errors. The correlation was computed between the completed set of word discrimination tests and reading achievement and not found to be significant. However, no information is reported on the

correlation between the performance of the subjects in perceiving correct letter sequences and their reading achievement.

Summary

While some research has been done on the relationship between the perception of sequence and reading achievement, no definitive conclusions can yet be drawn about the significance of this relationship. That young children tend to make many errors of letter transposition has been substantiated by several studies. Whether or not this is significant enough to influence the child's reading achievement appears to remain open for further investigation. This investigation is one of the purposes of the present study.

RESEARCH ON FINGER DIFFERENTIATION

Introduction

The study of finger differentiation has arisen out of studies in disturbances of the body schema. In these studies the specific ability under investigation has actually been finger agnosia - the loss of the ability to name the fingers or to point to named fingers. This loss of 'finger sense' is the result of brain lesions and often noted concomitantly with it are disturbances in right-left orientation, spelling disorders, and difficulty with digits and computations (Gertsman (1924), Kinsbourne and

Warrington (1962)).

Research Studies

Finger differentiation, one factor upon which this study concentrates, has been identified by Kinsbourne and Warrington (1963) as a developmental process in the young child's maturation. They view it as an awareness of the spatial position of the fingers in relation to each other and test for it by requiring the child to make discriminations "based on the classification of sensory input from the fingers in terms of the individual fingers tested in their correct spatial arrangement (p. 132)."

Their study of the developmental aspect of this ability was carried out on ninety nursery school children from five to seven and a half years of age. Their test for this included three of the five tests which they had previously used to test for finger agnosia. These three tests measured finger differentiation and finger order or sequence.

They found a developmental increase in performance with increasing chronological age. The following table shows the percentages of subjects who were successful at each age level:

TABLE I

MATURATIONAL INCREASE IN
FINGER DIFFERENTIATION

Test	Percentage of Subjects Passing in Each Age Group			
	4 1/2-5 1/4 yrs.	5 1/4-6 yrs.	6-6 3/4 yrs.	6 3/4-7 1/2 yrs.
1. The finger differ- entiation test	26.1	45.4	83.3	95.5
2. The "in-between" test	17.4	31.8	66.7	95.5
3. The block test	30.8	54.8	77.3	90.0

Kinsbourne and Warrington suggest that this developmental ability need not be regarded as an isolated one but may be related to a wider context of abilities through which the child is able to perceive sensory data from his environment to be processed internally.

In another study, Kinsbourne and Warrington (Money, 1966) found that subjects with finger agnosia made a higher proportion of letter-order errors in spelling than the three other groups in the study. These included sixteen aphasic subjects; fifteen subjects with right-hemispheric lesions; and thirteen subjects who evidenced no disease affecting the brain and were thus used as a control group. The twelve subjects who were in the finger agnosia group had failed to pass the test of finger differentiation and order - the same test used in their study of finger differentiation. All subjects were adult patients who had been referred on suspicion of cerebral cortical disease.

Spelling ability was tested orally, using one hundred words from Schonell's graded word spelling lists. Those subjects who got less than twenty words correct or who made fewer than twenty errors were excluded from the analysis. This excluded only one from the finger agnosia group and either two or three from each of the other three groups.

The spelling errors for each of the groups were classified as extraneous letters; letter-order; vowel substitutions; omissions; and reduplications. Errors of

omission and vowel substitution did not discriminate between the groups but the finger agnosia group had a higher proportion of letter-order errors than any of the other groups.

Kinsbourne and Warrington feel that this relationship "appears to reflect an underlying more general difficulty in processing information (both verbal and non-verbal) in terms of spatiotemporal sequence (p. 81)."

In a study by Benton (1959) the developmental aspects of what he called finger localization were studied. His test for finger localization included three tasks:

(1) the identification, with the aid of vision, of a single finger which had been touched.

(2) the identification, without the aid of vision, of a single finger which had been touched.

(3) the identification, without the aid of vision, of a pair of fingers simultaneously touched.

Each hand was tested ten times on each of the tasks. There was thus a total of sixty items. The subject indicated his answer on a schematic drawing of the right or left hand (whichever was being tested) by either pointing to the finger(s) touched, naming it, or saying its number.

These tasks appear to measure the child's perceptual awareness through tactual stimulation but not an awareness of the spatial order or arrangement of his fingers. They thus seem to correspond to the first test in the Test of Finger Differentiation which Kinsbourne and Warrington

used.

Benton tested 158 school children who were aged six to nine years. These subjects all had an intelligence rating of 85-115. He found that on these three tasks of finger localization the subjects revealed a progressive development with age. At age six, 69.8 percent of the sixty responses were correct while, at age nine, 89.2 percent were correct. This, however, was still below the perfect or near-perfect performance of the average adult. The three tasks revealed distinct levels of difficulty, with the proportion of errors at each age level, increasing from the first to the third task.

Benton also classified the localization errors according to the fingers involved. From this he constructed a finger schema in which "the clearest components of the schema are the outer fingers which form its borders, while the inner components are less well differentiated (p. 71)."

Benton's test battery was used in Canada by Wake (Benton, 1959, p. 68-69) on 612 school children who were aged six to twelve years. He also found that the mean performance of the children in finger localization increased progressively with age. The mean performance of the twelve-year-old children was still slightly below that of the average adult.

Although the following study by Reed (1967) is not specifically related to the topic under investigation, it is included in this review as it represents one attempt to

study the possible relation of this area of finger localization and differentiation to reading achievement. It is the only study the researcher could locate which attempted to do this.

In this study, the laterality of finger localization errors was examined in relation to reading achievement for six-year-old first grade children and ten-year-old fifth-grade children. Reed hypothesized that for the six-year-old children who made more left hand localization errors, reading achievement would be lower than for those who made more right hand localization errors. For ten-year-old children, he hypothesized that for those who made more right hand localization errors, reading achievement would be lower than for those who made more left hand localization errors. His hypotheses were based on clinical findings of the performance of patients with cerebral lesions.

To 220 grade one children and 233 grade three children, Reed administered a finger localization test, the Weschler Intelligence Scale for Children, and the Gates Primary Paragraph Recognition (Grade One), or the Comprehension section of the Gates Diagnostic Survey Test (Grade Five).

He classified each age level into two groups. In the RLG (right lateralized group), he put those who had made several more errors on the right hand than on the left hand. In the LLG (left lateralized group), he put those who had made more errors on the left hand than on the right.

The data was analyzed by a multiple covariance analysis.

Since no difference resulted between the two groups at age six in reading achievement, hypothesis one was rejected. At age ten, the difference between the adjusted means of the two groups in reading achievement was significant at the .005 level. The members of RLG read less well than the members of LLG. Reed suggests that this indicates that among ten-year-old children who have some difficulty on a finger localization test there is some relation between reading achievement and the hand on which a greater number of errors occurs. A right hand localization deficit would be associated with limitations in the development of proficient reading skills.

Summary

The research findings presented here suggest that difficulties in finger localization and in finger differentiation and order are to be found in the normal school population. The implication of some of these studies is that these abilities are related to the acquisition of other abilities by children. In one study, reading was examined as one of these abilities. However, this study was limited to the relation of reading to finger localization. Kinsbourne and Warrington (Money, 1966) found that a group of patients with reading retardation failed their test of finger differentiation and order. They felt that these difficulties, as well as other exhibited by

the patients, were based on difficulties in sequential ordering. These however, were patients suffering from cerebral cortical deficits.

In the present study, the normal school population was used to examine whether reading retardation and finger differentiation and order are related to each other and to difficulties in the perception of sequence.

CHAPTER III

THE EXPERIMENTAL DESIGN

INTRODUCTION

In the design of this study, consideration was given to the selection of the sample, to the test instruments to be used, and to the procedures to be followed in testing. For the examiner-constructed tests, it was necessary to run a pilot study. Following the collection of all the data, it was analyzed by statistical procedures. In this chapter, a description will be given of each of these aspects of the experimental design as it was carried out by the researcher.

SAMPLE

One school, in a mid socio-economic area of Edmonton, was originally designated by the officials of the Edmonton Public School Board for this research. Using Blishen's Occupational Class Scale (Blishen, Jones, Naegele, Porter, 1961, pp. 477-485) the majority of subjects in this 'mid' category would come from homes of skilled and semi-skilled workers. This would place them in categories four or five on this scale although, drawing from a normal distribution, there would be some deviations above or below these categories. Few children in this area came from non-English

speaking homes.

Of the 107 grade two pupils in this school, nine were eliminated for the following reasons:

(1) One was over the nine year age limit.

(2) Seven had intelligence quotients well outside the 90-120 range as determined by a measure such as the Stanford-Binet Scale.

(3) One was experiencing reading difficulties because of a second language problem.

From the remaining ninety-eight pupils, the researcher attempted to select thirty achieving readers and thirty non-achieving readers as these groups had been defined for this study.

Since it was not possible to get the thirty non-achieving readers from this school, permission was obtained from the Edmonton Public School Board officials to test an additional twenty pupils in another school designated by them as mid socio-economic. Twelve non-achieving readers were selected from this group to complete the sample.

SELECTION OF SAMPLE

The ninety-eight subjects in School I were given the California Short-Form Test of Mental Maturity - Level I by the researcher. Ten groups of subjects were tested with each testing session lasting for approximately one hour. Ninety of these subjects fell within the 90-120 range of

intelligence.

These ninety subjects were then given the Metro-politan Reading Achievement Test - Primary II. This test was administered to groups of fifteen by the researcher. The following test procedure was maintained constant for each group:

(1) The students were given the test of Word Knowledge.

(2) The test of Word Discrimination was presented by the examiner.

(3) A short break period was provided.

(4) The students completed the sentences section of the test of Reading Comprehension.

(5) They returned to the classrooms for morning or afternoon recess.

(6) The students returned after recess and completed the paragraph reading section. This was the longest section of the test.

On the basis of their performance on this test, those readers who could be classified as achieving or non-achieving were selected. At this point it was necessary to obtain the second school from the Edmonton Public School Board from which students could be drawn for this research.

Here twenty readers who were recognized as non-achievers were singled out by their classroom teachers. These students were then given the California Short-Form

Test of Mental Maturity - Level I in two groups of ten students.

Eighteen of these students fell within the 90-120 range of intelligence. The Metropolitan Reading Achievement Test - Primary II was given to the eighteen students as one group. From these it was then possible to select the twelve non-achievers to complete the sample.

The sixty children isolated for the sample were then seen individually by the researcher for a vision screening on the Keystone Telebinocular. The six subjects who were not able to pass the vision screening exhibited different types of vision difficulties. It was possible to replace these subjects with six others from the test population.

In the selection of the sample, no consideration had been given to the sex of the subjects. The distribution of male and female subjects in the final sample was thus completely a random outcome. As Table II reveals, the mean age of both groups was very close, although there was more variation in age for the non-achieving group.

The mean intelligence quotient for the achieving group was 7.13 points higher than that of the non-achievers. Table III presents the range of intelligence quotients for each group of readers.

TABLE II
SUMMARY OF TEST SAMPLE

Children of Sample	Sex		Total	Mean Age	Standard Deviation	Mean Intelligence	Standard Deviation
	Male	Female					
Achieving Readers	15	15	30	94.36	3.51	107.20	5.56
Non-Achieving Readers	22	8	30	94.97	4.61	100.07	5.82
Total	37	23	60	94.80	4.06	103.63	6.69

TABLE III

THE PERCENTAGE OF READERS AT
EACH LEVEL OF INTELLIGENCE

Range of Intelligence Quotient	Percentage of Achieving Readers in IQ Range	Percentage of Non-Achieving Readers in IQ Range
90-94	0	16 2/3%
95-99	6 2/3%	43 1/3%
100-104	26 2/3%	16 2/3%
105-109	33 1/3%	10%
110-114	23 1/3%	13 1/3%
115-119	10%	0

From Table III it can be seen that, even within the intelligence range accepted for this study, there existed a difference in the two groups. While only $6\frac{2}{3}$ percent of the achieving readers fell below an intelligence quotient of one hundred, 60 percent of the non-achieving readers did. None of the non-achieving group had an intelligence quotient above 114.

The subject's performance on any two of the tests in Table IV was used to determine his group placement. For the achieving readers, performance was above the seventy-fifth percentile for all except seven readers on the Word Discrimination Test. The student's auditory acuity and auditory discrimination would affect his performance on this test.

The non-achieving readers evidenced a wide range of performance in their reading achievement. Two of the students were comparable to achieving readers in Word Discrimination but below the thirty-fifth percentile on the remaining two sections of the test. While these students were able to discriminate words, they were still experiencing reading difficulties. One student scored above the forty-fifth percentile on Word Knowledge but was well below on the other two sections. No student in this group placed above the forty-fifth percentile in Reading Comprehension.

That the non-achieving readers selected for this study evidenced a wide variation in performance was partly due to the limitation imposed by the population available. This limitation restricted the adequacy of this sample.

TABLE IV

SUMMARY OF STUDENT PERFORMANCE ON THE
METROPOLITAN READING TEST

Student Group	Percentile Ranking	No. of Students in Word Knowledge	No. of Students in Word Discrimination	No. of Students in Comprehension
Achieving Readers	90-98	18	15	11
	90	0	0	2
	80-90	5	8	10
	80	2	0	6
	75-80	0	0	1
	75	5	0	0
	70	0	4	0
Non-Achieving Readers	50-65	0	3	0
	Total	30	30	30
Non-Achieving Readers	Above 50	0	4	0
	40-50	2	3	2
	40	1	2	1
	30-40	8	1	4
	30	3	4	4
	20-30	4	5	2
	20	2	1	6
	10-20	4	3	5
	10	2	3	2
	2-10	4	4	4
Non-Achieving Readers	Total	30	30	30

TEST INSTRUMENTS

Standardized Tests

1. California Short-Form Test of Mental Maturity - Level 1. In defining a non-achieving reader, it was stated that he would be one who fell within a designated range of intelligence. The range of intelligence accepted for the subjects in this study was 90-120 as measured by the California Short-Form Test of Mental Maturity - Level 1 (1963). It consists of seven sub-tests and provides both a language and a non-language score. The combined score from these two sections was used as the measure of intelligence. All response items in this test are in the form of pictures with the student being asked to indicate his choice by marking the box below the appropriate picture.

The sub-tests of the California Short-Form Test of Mental Maturity are grouped according to four factors:

(1) Logical Reasoning.

Subtest 1 - Opposites. From three drawings, the student is asked to select the one which is opposite to a given one. There are twelve items in this test.

Subtest 2 - Similarities. The student is asked to determine how two drawings are alike and, from a choice of three more, he is to select the one which is related to these two. This section also contains twelve items.

Subtest 3 - Analogies. Here the student must recognize how two pictures are related. From three more

pictures he must then choose the one which is related to a third picture in the manner in which the first two are related. There are twelve items here.

(2) Numerical Reasoning.

Subtest 4 - Numerical Values. The first eight items of this section test the student's understanding of concepts such as heaviest or lightest. The last six items require the recognition of numerical sequences. The subject is required to select the picture which matches a sentence read by the examiner.

Subtest 5 - Number Problems. In these ten problems, the student is shown a picture of a numerical quantity. From three others he is asked to select the resulting one when a certain numerical change is made on the first and indicate his choice by marking it.

(3) Verbal Concepts.

Subtest 6 - Verbal Comprehension. From a choice of four pictures, the student is to mark the one which matches a word or phrase read by the examiner. There are twenty-five items on this test.

(4) Memory.

Subtest 7 - Delayed Recall. The student is required to recall facts or ideas of a story which was read at the beginning of the test. He marks the one picture from a choice of four which matches a sentence about the story read by the examiner. There are fifteen items to be done in this way.

In a review of the 1963 revision of this test, Stanley (Buros, 1965, pp. 694-697) says that the California Short-Form Test of Mental Maturity is most useful for measuring mental capacity from kindergarten to third grade. His main criticisms of the test center on the lack of care given to the editing of items and the poor quality of the art work.

In a review of the 1957 edition, Burt (Buros, 1959, pp. 433-435) says it is an excellent instrument for measuring general capacity but not distinct mental processes or mental development.

Three factors of the California Short-Form Test of Mental Maturity made it advantageous for the researcher to use this measure of intelligence:

(1) The results obtained were relatively uninfluenced by the student's level of facility in the reading skills.

(2) Each of the sub-tests were short with a wide variety in the different tasks that each one involved.

(3) The total test was designed to be administered in one sitting of less than one hour.

In completing this test the subject's performance can be influenced by many variables. It is possible that one of those affecting the performance of some of the subjects here is the perceptual ability under study - the perception of sequence. In this situation, such a difficulty may mar a true picture of a subject's ability.

2. The Metropolitan Reading Achievement Test -

Primary II. This test is designed for use in Grade Two and provides a measure of three reading skills - word knowledge, word discrimination and reading comprehension. Each of these is administered as separate tests and is interpreted separately by percentile rankings, grade levels and stanines.

In each test, the student indicated his choice of answer by marking the appropriate box. He was instructed to do the best that he could with a word if he was not able to read it. No words were read for the students except in the beginning samples.

Test 1 - Word Knowledge - is a measure of vocabulary and word recognition. This test contains two different measures of the child's word knowledge. In the first seventeen items he is asked to match one of four words with a picture. In the remaining twenty items, the child must read a sentence and choose, from the four words which follow, the one which best completes the sentence.

Test 2 - Word Discrimination - is a thirty-five item test of phonic ability in which the child is asked to choose from four words the one which is presented orally by the examiner. Here the child must be able to discriminate both auditorily and visually, for he must hear the sound correctly and associate the sound of the word with its printed form. Each word is read both in isolation and in a specific context. The authors of the test state that this is a

relatively easy test for many pupils at the end of Grade Two.

Test 3 - Reading (entitled Reading Comprehension in this study). This section of the test actually provides two measures of comprehension. Part one measures the child's ability to read and understand sentences by asking him to choose, from three, the one which describes a picture correctly.

Part two measures the child's ability to read paragraph material of increasing length and difficulty. Each selection is followed by questions which are mostly factual in nature. There are ten selections to be read and a total of thirty-seven multiple-choice questions to be answered.

The Metropolitan Reading Test appears to be well accepted as a survey test of reading achievement. H. A. Robinson (Buros, 1968, p. 312) describes it as "one of the best survey tests of reading achievement on the market today for the elementary grades. It has been carefully planned, carefully tested, and well produced."

A similar view is expressed by McKim (Buros, 1968, p. 174) and by Hobson (Buros, 1968, p. 174) who describes it as "outstanding for general purpose every-pupil measurement and evaluation in reading."

The yielding of three independent measures of different aspects of reading achievement was a factor of this test which made it appropriate for use in the present

study. It was thus possible to examine each of these three different aspects of reading as they related to the perceptual ability studied here.

Test of Finger Differentiation

A complete copy of this test is found in Appendix A as well as a copy of the scoring sheet used to record each student's response.

This test was developed by Kinsbourne and Warrington in London, England (1963), to discover if the ability to differentiate sensations from the fingers and to perform tasks requiring an awareness of the spatial arrangement of the fingers occurred at particular stages of maturation for the young child. To carry out their research into this, they developed three testing procedures. These are very similar to three of the tests they had used to test for finger agnosia as a lack of awareness of the sequence of the fingers in patients with cerebral cortical diseases. The three tests are:

Test 1 - The finger differentiation test. This tested the subject's ability to differentiate each finger on both his hands as individual entities distinct from the total finger mass. The subject was asked to tell the examiner how many fingers she was touching - one or two - without his actually seeing this being done. There were four trials for each hand.

Test 2 - The "in between" test. This test required the subject to be aware of the order of his fingers on his

hands for he had to know how his fingers are placed in relation to one another in order to answer the questions. The examiner touched two fingers on one hand and the subject was required to tell how many fingers were between those touched. This was again performed without the subject's use of vision. There were four trials on each hand so arranged that the answer for each hand was once "none", twice "one", and once "two".

Test 3 - The finger block test. In this test, the student again had to be aware of the spatial arrangement of his fingers in order to match the blocks. Here a wooden block was placed in the subject's hand. The block was so carved on one end that when it fit into the student's hand two fingers were more flexed than the other two. He was then shown a set of four blocks exactly like those being used and asked to pick the one which was like the one he was holding. The hand holding the block was not visible to the subject.

To ensure that the subject did not see which fingers were being touched or view the block in his hand, it was decided to use a wooden box in which the end facing the examiner was open, while a cloth covered the end facing the student. The student then placed his hand or hands under the cloth while the examiner, sitting opposite the student, conducted the test.

There was no time limit on this test but it generally required only five to ten minutes to complete the three

sections. Each test was preceded by illustrated explanations under direct vision and explained until clearly understood by the student.

Letter-Sequence-in-Words Test

Since one of the purposes of this study was to discover whether the perception of the sequence of letters in words was a source of difficulty for the reader at the level chosen, it was necessary to construct a test to measure this. A copy of this test is to be found in Appendix B.

All of the words used in this thirty-item test appeared in either or both of the New Curriculum Foundation Series and the Ginn Basic Readers at the grade two and four levels. These two series were chosen as a source because they are the two major reading series as outlined in the Program of Studies (1969) from the Department of Education for use in Alberta schools.

It was decided to make half of the words selected common words, occurring often in grade two level reading. Those words selected from the grade two readers were also checked for their frequency of occurrence in the Teacher's Word Book of 30,000 Words (Thorndike, 1944) or Clarence Stone's Revision of the Dale list of 769 Easy Words (Stone, 1957). The other half of the words were designed to be too difficult for most grade two students. These words were selected from the grade four level readers and checked against the two listed sources for their frequency of

occurrence. By this means, the subject's perception of letter sequence with both familiar and unfamiliar words could be compared.

To limit the task to the actual perception of sequence and to reduce the influence of other variables such as memory, a matching-type exercise was devised. The words selected were listed on the left-hand side of the page. Across from each word were printed four words containing the same letters, with only one being exactly like the original. The other three each had a change in the sequence of the letters.

The student was asked to look at the word on the left-hand side of the page, then across at the four words following to find the one just like the first one and circle it. The total score was the number correct out of the thirty items.

An example of an item is:

people		poeple	peolpe	peopel	people
--------	--	--------	--------	--------	--------

Four criteria were used in making the alternate choices for each selection:

(1) The general configuration of all choices was kept as much like the actual word as possible.

(2) Only one sequence change was introduced into any one choice.

(3) No extraneous letters were added, no letters were deleted, and no rotations or reversals of letters

were introduced.

These three criteria ensured that the test items would be discriminatory as measures of sequence perception. Gross differences in shape were avoided as influencing variables by criteria one and two. Criterion three eliminated extraneous factors which are not part of this study.

(4) Based on research by Hill (1936), Kennedy (1954), and Marchbanks and Levin (1965), the alternate choices generally contained internal changes in test items except for the five word reversals included. This required the student to use the internal sequence of letters.

The Kuder-Richardson formula 20 reliability coefficient (Ferguson, 1966, p. 377) for this constructed test was computed at .88 by item analysis.

Sequence Test of Letter-Like Forms

It was decided to use these forms as a measure of the child's perception of sequence when the effects of learning of alphabetic letters are not present. These twelve letter-like forms were arranged in groupings to correspond to words and were reduced in size to be exactly comparable to the print used with the words. From the results of a pilot run on this test, it was decided to make the groupings of different lengths, varying from three to six forms per word-like grouping. The test consisted of twenty-five items and was exactly comparable in design and procedure to the Letter-Sequence-in-Words Test. A copy of the test is to be found in Appendix C.

An example of a test item is,

$\begin{array}{c} \pm \uparrow \epsilon \downarrow \\ \parallel \\ \downarrow \epsilon \uparrow \pm \end{array} \quad \begin{array}{c} \downarrow \epsilon \uparrow \pm \\ \uparrow \pm \epsilon \downarrow \end{array} \quad \begin{array}{c} \pm \uparrow \epsilon \downarrow \\ \downarrow \epsilon \uparrow \pm \end{array} \quad \begin{array}{c} \pm \uparrow \epsilon \downarrow \\ \downarrow \epsilon \uparrow \pm \end{array} \quad \begin{array}{c} \pm \uparrow \epsilon \downarrow \\ \downarrow \epsilon \uparrow \pm \end{array}$

As much as possible, the criteria used in arranging the sequence changes for each of these test items was the same as that used for the items on the Letter-Sequence-in-Words Test.

(1) The general configuration of the groupings were kept much like the first one.

(2) Only one change in sequence was introduced into any item at any one time.

(3) No transpositions were introduced on any of the forms.

(4) Unless a reversal of the grouping was used, one of the alternate choices had a change in sequence near or at the beginning, one in the middle and one near or at the end of the grouping.

The Kuder-Richardson formula 20 reliability coefficient (Ferguson, 1966, p. 377) was computed at .74 by item analysis for this test.

PILOT STUDY

To test the effectiveness of the two examiner constructed tests, to acquire facility with the finger differentiation test, and to discover any complications that

might arise, a pilot study was run using these three tests on a sample of ten children.

Permission was obtained to select ten grade two children from a school in the Edmonton Public School System. The children selected for this pilot run were in the seven to nine year age range. Their intelligence ratings as listed from previous intelligence testing was between 90-120. On the basis of teacher judgment and tests, five of the children were identified as achieving readers and five as non-achieving.

Each of these children were then seen individually by the researcher when they were given these tests:

- (1) The Letter-Sequence-in-Words Test
- (2) The Test of Finger Differentiation
- (3) The Sequence Test of Letter-Like Forms

The administration of tests one and three was interchanged.

Revisions and changes were made in each of the three tests on the basis of the pilot run. In completing the Test of Finger Differentiation, some of the children flexed or raised their fingers in order to discover how many fingers were being touched or how many were between those touched. In the finger block test, some wanted to feel the blocks. Because of this, it was decided that each of the three tests would be preceded by a statement telling the child not to move his fingers in Tests 1 and 2 or his hand in the block test, Test 3. However, because it would be difficult to prevent the child from doing this, a third

scoring category was introduced. The child could thus receive a "pass", or "fail" or "moved" for each question. He was marked in this third category if he moved his fingers in answering the question. In scoring the test, this "moved" category was subdivided into PM - those who passed six or more items but used movement on one or more of the remaining items; and FM - those who failed to get six items correct and used movement on one or more of the remaining items.

Based on the performance of these ten subjects on the Letter-Sequence-in-Words Test, as described in Table V, thirteen of the thirty items were removed and replaced by new items derived in the same manner as the first ones, and so as to maintain the proportion of familiar and unfamiliar words - one half of each.

The reasons for changed included:

- (1) Three items received no incorrect choices.
- (2) Five items received one incorrect choice.

(3) Five items were incorrectly chosen on the basis of letter similarity rather than sequence of letters. This occurred in words with letter pairs such as b-d, q-p, u-v, n-m. Since the inclusion of items involving rotations and reversals would involve factors other than the perception of sequence, these items were eliminated.

The performance of these same subjects on the Sequence Test of Letter-Like Forms revealed that this test as it was originally constructed was not discriminatory

TABLE V

RESULTS FROM PILOT RUN ON LETTER-SEQUENCE-IN-WORDS TEST.

Achieving Readers		Non-Achieving Readers	
Subject	No. of items correct	Subject	No. of items correct
1	28	1	29
2	29	2	13
3	27	3	14
4	29	4	7
5	20	5	18

enough to measure the child's perception of sequence. On this test, the forms had been reproduced so that they corresponded in size to those given in the Gibson, Gibson, Pick and Osser report (1962). Also all the groupings used contained only three letter-like forms. This limited the number of sequence changes which could be introduced into the items. As a result, in many of the items only one of the four choices began with the same letter-like form as the original. In these cases, the subject did not have to look beyond the first form in the groupings to make his choice. Also, because of the small number of changes which could be made in sequence, it was not possible to maintain the general configuration of the original in the four choices.

On the basis of this, it was decided to make this test parallel the test with words with the main difference being that there would be no meaning attached to these word-like groupings. The forms were reduced in size to correspond to the size of the print used on the Letter-Sequence-in-Words Test. To achieve this, they were reduced in size by approximately 75 percent. Their shape and orientation was maintained constant in this reduction. These forms were then grouped into combinations of varying length in the following proportions:

Three letter-like forms - 20 percent
Four letter-like forms - 32 percent
Five letter-like forms - 32 percent
Six letter-like forms - 16 percent

In Dewey's list (Dewey, 1923) of the most commonly occurring words in English, 118 words occur one hundred times or more. Of these 118 words, ninety-three or 79 percent of them are words containing from three to six letters. This range was chosen as the one to be observed for any combination of forms in the Sequence Test of Letter-Like Forms. To maintain an equal usage of all the forms, each one was made to occur between eight to ten times in the test.

It was then possible to make the criteria governing the alternate choices for each item the same as that used in making those for the Letter-Sequence-in-Words Test.

TESTING PROCEDURES

During the month of May, 1970 the subjects in both schools were tested on the California Short Form Test of Mental Maturity - Level 1, and the Metropolitan Reading Achievement Test - Primary II. Following a vision screening on the Keystone Telebinocular, the sample for this study was completed.

These subjects were then tested individually by the

researcher with the following tests:

- (1) The Letter-Sequence-in-Words Test
- (2) The Test of Finger Differentiation
- (3) The Sequence Test of Letter-Like Forms

The administration of tests one and three was interchanged randomly. While this placed the Test of Finger Differentiation in a constant position where it was not possible to control the effects of order on it, the procedure helped randomize the effects of learning on these two tests. This was also a control on the possibility of tiring effects occurring if these two very similar tests had followed each other.

All testing was completed by the end of May, 1970.

ANALYSIS OF DATA

The data for this study was analyzed by the following I.B.M. 360 computer programs:

(1) Dest 02

(a) By this program, Pearson product-moment correlations were computed between all the variables for the three groups in this study.

(b) Partial correlation coefficients were obtained with the effects of intelligence removed, for selected variables.

(2) ANCV 10

By the analysis of covariance, the relationship

of each of the four finger differentiation groups to selected variables was computed, controlling for the effects of intelligence.

(3) Test Ø4

By item analysis, the Kuder-Richardson formula 20 correlation coefficient was obtained for each of the examiner-constructed tests.

(4) A test of the difference between two correlated proportions was run on the three finger differentiation tests to determine whether there were significant differences in the proportions passing each test.

CHAPTER IV

THE FINDINGS OF THE STUDY

INTRODUCTION

This chapter will present the findings of the study in four main sections. In the first section, data on student performance on the tests administered will be presented. In the second section, the statistical analysis yielding correlation coefficients between the variables in hypotheses one, two and three will be discussed by centering the discussion on these hypotheses. Thirdly, the results of the analysis of covariance performed for hypothesis four will be presented. Finally, some additional findings revealed by the examiner-constructed tests will be given.

STUDENT PERFORMANCE ON THE TESTS

Reading Achievement

The mean scores and the standard deviations on each of the tests of reading achievement for both achieving and non-achieving readers are presented in Table VI.

The mean scores on each of these tests reflect the design which was built into the sample selection. For the achieving readers, the mean percentile ranking on each test is relatively high. The mean percentile ranking of 85.77 on Word Discrimination is the lowest of the three. A

standard deviation of 12.94 on this test reveals that it had a greater variation in performance than either Word Knowledge with a standard deviation of 8.30 or Reading Comprehension with a standard deviation of 6.49.

For the non-achieving readers, the mean percentile rankings on the three tests range from 22.27 on Reading Comprehension to 30.17 on Word Discrimination. For this group of readers, the mean percentile on Word Discrimination is the highest of the three. Again, this test shows the greatest variation in performance. The standard deviation of 21.86 is almost twice the size of the standard deviations on each of the other two tests. On all three tests of reading achievement, the standard deviations of the non-achievers reflect a much greater variation in performance than that of the achieving group.

While the mean percentiles on Word Knowledge and Reading Comprehension are comparable within each group, both groups reflect differing performance on Word Discrimination. For the achieving group, this was the lowest mean percentile attained while, for the non-achieving group, it yielded the highest mean percentile. For both groups, this test revealed the greatest variation in performance.

It may be that the influence of variables other than reading ability had some effect in creating this variation in performance on Word Discrimination. Important to the student's performance on this measure of his word discrimination were his auditory acuity and his auditory

TABLE VI

STUDENT PERFORMANCE ON READING ACHIEVEMENT AND
SEQUENCE PERCEPTION TESTS

Tests	Possible Score	Achieving Readers Mean	Achieving Readers Standard Deviation	Non-Achieving Mean	Non-Achieving Readers Standard Deviation
Word Knowledge	98% ile	89.67	8.30	24.77	12.79
Word Discrimination	98% ile	85.77	12.94	30.17	21.86
Reading Comprehension	98% ile	87.70	6.49	22.27	11.98
Letter-Sequence-in- Words Test	30	27.30	2.10	22.33	6.73
Sequence Test of Letter- Like Forms	25	22.70	1.93	20.80	3.88

discrimination, for the test words were presented orally by the examiner. These variables could have little effect on his performance on the other two measures of reading achievement for they were completed silently by the student with no additional aid after the instructions had been clearly understood.

Sequence Tests

Table VI also shows the mean scores and the standard deviations on the two sequence tests constructed by the examiner.

Letter-Sequence-in-Words Test. A mean score of 27.30 out of 30 for the achieving readers on this test reveals that they did not experience much difficulty with it. A mean score of 22.33 for the non-achieving readers shows only a five point difference and indicates that this was not a difficult task for them either. However, a standard deviation of 6.73, for the non-achieving group, reveals a greater variation in performance than the 2.10 standard deviation of the achieving group.

The reliability of this test as a measure of the perception of letter sequences in words was analyzed by item analysis. The Kuder-Richardson formula 20 reliability coefficient was found to be .88 . This left 12 percent of the variance of this test attributable to error. The reliability coefficient thus appears to be sufficiently high to accept this test as a reliable measure of the

perception of letter sequence (Ferguson, 1966, p. 377).

The item analysis of the Letter-Sequence-in-Words Test gave a mean of 24.75 for the total sample. This again indicated a high level of performance on this test. The proportions of subjects passing each test item is indicated by the difficulty index of the item. Those items which had a difficulty index of less than 80 percent are listed in Table VII.

Only eight of the words used in this test caused difficulty to more than 20 percent of the students. Two of these were grade four words (unfamiliar), while the other six were grade two words (familiar).

Sequence Test of Letter-Like Forms. The difference in the performance of the two groups on this test was less than two points. Mean scores of 22.70 for the achieving readers and of 20.80 for the non-achieving readers reveal that neither of these groups experienced much difficulty with this test. The variation in the performance of the non-achieving readers, with a standard deviation of 3.88, was greater than that of the achieving readers.

The Kuder-Richardson formula 20 reliability coefficient of this test was found to be .74 . This meant that 26 percent of the variance of this test could not be attributed to variations in the true score (Ferguson, 1966, p. 377). While this reliability coefficient of .74 is not as high as that for the Letter-Sequence-in-Words Test, this

TABLE VII
MOST DIFFICULT ITEMS ON LETTER-
SEQUENCE-IN-WORDS TEST

Percentage of Students Passing Item			
	50 - 59%	60 - 69%	70 - 79%
Grade two Words	breakfast picture	policeman	chimney pencil traffic
Grade four Words	scenery		dignity

test can be accepted as a fairly reliable measure of the perception of sequence in letter-like forms.

The item analysis of this test revealed that only four items had a difficulty index of less than 80 percent. Of these items, three were combinations of five letter-like forms and one consisted of six letter-like forms. These five items, which caused difficulty to more than 20 percent of the subjects, were some of the longer test items.

Test of Finger Differentiation

Since this test consisted of three subtests, a total of ninety scores was recorded for each group of readers. In Table VIII, the number of subjects placing in each of the four categories is presented. Each total number represents the number of performances out of ninety which fell in each category for the group of thirty readers.

Table VIII shows a total of 64 passes out of 90 for the achieving readers on the three finger differentiation tests. This represents 71.11 percent of the total number possible. For the non-achieving readers, the 50 recorded passes represent 55.56 percent of the total of 90 performances. Both groups record practically an equal number of failures in their total performance on the three tests.

For both groups of readers, but particularly for the non-achieving group, Test 2, the "in-between" test, revealed the greatest variation in performance. On this

TABLE VIII

STUDENT PERFORMANCE ON THE TEST
OF FINGER DIFFERENTIATION

Sample Group	Finger Differentiation Test	No. of Subjects in each Category			
		P	PM	F	FM Total
Achieving Readers	Test 1	23	2	4	1 30
	Test 2	14	4	7	5 30
	Test 3	27	1	1	1 30
	Total	64	7	12	7 90
Non-Achieving Readers	Test 1	21	4	3	2 30
	Test 2	6	5	6	13 30
	Test 3	23	3	2	2 30
	Total	50	12	11	17 90

test, nineteen of the non-achievers placed in the F and FM categories as against eleven subjects in the P and PM categories. For the achieving readers, there was still a higher proportion of subjects in the P and PM categories, although not as high a proportion as in Test 1 and Test 3.

A test of the differences between proportions (Ferguson, 1966, pp. 179-180) was used, comparing the proportions of subjects passing and failing each test, to find out if there were any significant differences in the results revealed by each test. The Z - score, resulting from the comparison of Test 2 and Test 3, was significant beyond the .01 level. This indicated that significantly more subjects passed Test 3 than Test 2. While these two tests had been identified as measures of finger differentiation and order, they resulted in significantly different performances from this test sample.

When the performance in the two movement categories is combined, fourteen of the achieving readers are found to be using movement as an aid. For the non-achieving readers the number using movement on the three tests is twenty-nine. Thus twice as many non-achievers as achievers used movement in answering the questions on this test.

Movement or kinesthetic perception can serve as an aid or reinforcement to what one hears or sees. Some of the non-achieving readers may here be depending on this kinesthetic perception to reinforce what they feel is the correct answer or to help them reach this answer. They may

also feel an uncertainty, arising from their lack of achievement, which makes it necessary for them to seek this reinforcement by movement.

CORRELATIONS BETWEEN VARIABLES

To test hypotheses one, two and three, Pearson product-moment correlation coefficients were computed between reading achievement as measured on each section of the reading test and the scores obtained on the Letter-Sequence-in-Words Test and the Sequence Test of Letter-Like Forms. In addition, the correlation coefficient was computed between the scores on these two sequence tests. The partial correlation coefficients between these variables, with the effects of intelligence removed, were then computed. To determine the levels of significance of the "t" scores yielded with these partial correlation coefficients, a table of critical values of "t" was consulted in Ferguson (1966, p. 406). The correlations between intelligence and the scores on each of the sequence tests is given in Appendix D.

Hypothesis One

There is no significant correlation between the ability to perceive letter sequences and reading achievement in grade two children, seven to nine years old, when the effects of intelligence are removed, for

- (a) achieving readers
- (b) non-achieving readers

The partial correlation coefficients between reading

TABLE IX

CORRELATIONS BETWEEN READING ACHIEVEMENT AND SCORES
ON LETTER-SEQUENCE-IN-WORDS TEST

Reading Test	Achieving Readers			Non-Achieving Readers		
	Partial Correlation Coefficient with Letter Sequence Score	"t" value	Level of Sig.	Partial Correlation Coefficient with Letter Sequence Score	"t" value	Level of Sig.
Word Know- ledge	-.26	-1.40	ns	.27	1.46	ns
Word Discrimi- nation	-.22	-1.14	ns	.37	2.08	.05
Reading Compre- hension	-.11	-0.59	ns	.35	1.92	ns

Critical value of "t" at .05 level = 2.05

Critical value of "t" at .01 level = 2.77

(from Ferguson, 1966, p. 406)

achievement and letter sequence scores are presented in Table IX, with their levels of significance indicated.

For the achieving readers, a low negative correlation exists between the perception of letter sequences in words and reading achievement in Word Knowledge, Word Discrimination and Reading Comprehension, after the effects of intelligence have been removed.

For the non-achieving readers, when the effects of intelligence are removed, a low positive correlation exists between letter sequence scores and Word Knowledge and between letter sequence scores and Reading Comprehension. Neither of these correlations reach the .05 level of significance. However, a correlation of .37 between the letter sequence scores and Word Discrimination is significant at the .05 level.

Both Word Discrimination and the Letter-Sequence-in-Words Test are measures of visual perception. While performance on each one is influenced by variables such as their purposes or the method of administration, they are both designed to measure the same general ability. The relationship between these two measures is a significant one for non-achieving readers but not for achieving readers. This indicates that the ability to visually discriminate letter sequences in words is still an important factor in the word discrimination technique used by non-achieving readers. However, the achieving reader may no longer depend on this technique. Rather, he may be the master of many

different techniques, from which he can select the most expedient one for any particular situation. It may be that one factor in the reading difficulty of the non-achieving reader is his lack of mastery of different methods of word recognition.

Hypothesis Two

There is no significant correlation between the ability to perceive sequence in letter-like forms and reading achievement in grade two children, seven to nine years old, when the effects of intelligence are removed, for

- (a) achieving readers
- (b) non-achieving readers

The partial correlation coefficients, for each of these groups of readers, on the two variables - reading achievement and scores on the test of sequence perception in letter-like forms - are presented in Table X. As well, their levels of significance are indicated.

The correlation between the reading achievement of achieving readers and their perception of sequence in letter-like forms is a low negative one on both Word Knowledge and Word Discrimination. With Reading Comprehension, a correlation of .08 indicates that this relationship approaches very close to the zero point. This indicates almost a total absence of any relationship.

For the non-achieving readers, there is a low

TABLE X

CORRELATION BETWEEN READING ACHIEVEMENT AND SCORES
ON SEQUENCE TEST OF LETTER-LIKE FORMS

Reading Test	Achieving Readers			Non-Achieving Readers		
	Partial Correlation Coefficient with Sequence Score	"t" value	Level of Sig.	Partial Correlation Coefficient with Sequence Score	"t" value	Level of Sig.
Word Knowledge	-.15	-0.77	ns	.24	1.28	ns
Word Discrimination	-.15	-0.78	ns	.21	1.32	ns
Reading Comprehension	.08	0.43	ns	.47	2.74	.05

Critical value of "t" at .05 level = 2.05

Critical value of "t" at .01 level = 2.77

(from Ferguson, 1966, p. 406)

positive correlation of .24 between performance on the Sequence Test of Letter-Like Forms and achievement in Word Knowledge and a correlation of .21 between the sequence scores and Word Discrimination. Neither of these correlations is sufficiently strong to have predictive value. However, a correlation of .47 between Reading Comprehension and the scores on the Sequence Test of Letter-Like Forms is significant at the .05 level and approaches very close to the .01 level.

Thus similar low positive correlations are found to exist between the reading achievement of non-achieving readers and either measure of their perception of sequence. Using letter-like forms, the correlation of the sequence score with Word Discrimination does not reach the level of significance shown between it and the letter sequence score. However, in the Letter-Sequence-in-Words Test the same medium was used as in Word Discrimination. The Sequence Test of Letter-Like Forms does not bear this same relationship to Word Discrimination. This may be reflected in the lower correlation obtained.

The mean Reading Comprehension score attained by the non-achieving readers was their lowest measure of reading achievement. The high correlation it revealed with the Sequence Test of Letter-Like Forms may arise from a lack of meaningfulness in either of these tasks for these non-achieving readers. In their performance on Reading Comprehension, it was noted that, for many of these readers,

the selection of answers was almost completely a random choice selection. The Sequence Test of Letter-Like Forms had been so designed as to contain no meaning factor.

Hypothesis Three

There is no significant correlation between the ability to perceive letter sequences in words and the ability to perceive sequence in letter-like forms, when the effects of intelligence are removed, for

- (a) achieving readers
- (b) non-achieving readers

The partial correlation coefficients between each of these tests of the visual perception of sequence are presented in Table XI for each of the groups in this study.

As Table XI reveals, the correlation between performance on the Letter-Sequence-in-Words Test and performance on the Sequence Test of Letter-Like Forms is greatly dependent on the group of readers involved in the analysis.

A partial correlation of $-.03$ between the factors measured by these two tests for the achieving readers indicates that there is an absence of practically any relationship. The perception of letter sequences in words does not bear any relationship to the perception of sequence in letter-like forms for achieving readers.

They performed well on both of these tests, obtaining a mean score at approximately two points below

TABLE XI
CORRELATIONS BETWEEN PERFORMANCE ON THE
TWO SEQUENCE TESTS FOR BOTH GROUPS

	<u>Achieving Readers</u>			<u>Non-Achieving Readers</u>		
	Partial Correlation Coefficient with Sequence Test of Letter-Like Forms	"t" value	Level of Sig.	Partial Correlation Coefficient with Sequence Test of Letter-Like Forms	"t" value	Level of Sig.
The Letter Sequence-in- Words Test						

Critical value of "t" at .05 level = 2.05

Critical value of "t" at .001 level = 3.69

(from Ferguson, 1966, p. 406)

the total possible score on each of them. As well, the variation in performance on each, shown by the standard deviations, is relatively small. However, while they are able to perform equally well on both of these tasks, there does not appear to be some factor in common--namely sequence perception--which is determining their performance on these two tests.

For non-achieving readers, a very different situation exists. A high positive correlation of .62, independent of intelligence, exists between these two tests for this group of readers. This correlation is significant at the .001 level. It thus appears that the ability of the non-achieving reader to perceive letter sequences in words is positively and significantly related to his ability to perceive sequences in letter-like forms. It would appear that, for this reader, the Sequence Test of Letter-Like Forms and the Letter-Sequence-in-Words Test are measuring a common ability - the perception of sequence.

THE FOUR FINGER DIFFERENTIATION GROUPS AND SELECTED VARIABLES

Hypothesis Four

Within each of these groups of readers, there is no significant difference among the finger differentiation groups, controlling for intelligence, on

(a) Reading Test 1 - Word Knowledge

(b) Reading Test 2 - Word Discrimination

- (c) Reading Test 3 - Reading Comprehension
- (d) Letter-Sequence-in-Words Test
- (e) Sequence Test of Letter-Like Forms
- (f) Age

To analyze the performance of the four finger differentiation groups on each of the criterion measures listed in hypothesis four, an analysis of covariance was performed. The means of the four groups on each of these criterion measures were adjusted for differences in the intelligence means of each group (Winer, 1962, p. 579). A test of the homogeneity of within-class regression was not performed.

This analysis was performed for each group of readers. However, on the Test of Finger Differentiation, the majority of achieving readers were in the P - category. In Test 1, only one subject placed in the FM category. In Test 3, only one subject placed in each of the other three categories. As a result, a statistical analysis could not be performed for the achieving readers on Test 1 and Test 3 of the Test of Finger Differentiation.

For this group of achieving readers, an analysis of covariance was computed for the four finger differentiation groups from Test 2 only. The results of this analysis are presented in Table XII. For each of the criterion measures, the F-ratio, adjusted for intelligence, between the means of the four groups is presented with its probability of occurrence.

On all of the criterion measures, Word-Knowledge,

TABLE XII

ANALYSIS OF COVARIANCE ON TEST 2 OF THE
TEST OF FINGER DIFFERENTIATION FOR
ACHIEVING READERS

Criterion	Source	df	MS	Adj. F*	P
Word Knowledge	Group	3	22.57	.29	.83
	Error	25	77.23		
Word Discrimination	Group	3	78.65	.43	.74
	Error	25	183.93		
Reading Comprehension	Group	3	24.07	.55	.65
	Error	25	43.42		
Letter Sequence	Group	3	7.02	1.75	.18
	Error	25	4.01		
Letter-Like Forms	Group	3	6.38	1.83	.17
	Error	25	3.49		
Age	Group	3	9.83	.79	.51
	Error	25	12.37		

*Not statistically significant at the .05 level.

Word Discrimination, Reading Comprehension, Letter-Sequence-in-Words Test, Sequence Test of Letter-Like Forms and age, the F-ratio is not statistically significant and the probability of chance occurrence is high. The adjusted F-ratios of 1.75 and 1.83 between the means of the four groups on each of the sequence tests were the highest F-ratios obtained. However, a P of .18 for letter-sequence and of .17 for letter-like forms reveal that neither of these F-ratios approaches the level of statistical significance.

There is, thus, no difference between the four finger differentiation groups, created from the performance of achieving readers on Test 2 of the Test of Finger Differentiation, on the six criterion measures used in this study.

For the non-achieving readers, it was possible to perform an analysis of covariance on each of the three sections of the Test of Finger Differentiation. Table XIII shows the F-ratios, adjusted for intelligence, between the means on the criterion measures for each of the finger differentiation groups on Test 1. The F-ratio for the means of the four groups ranges from .19 on the criterion, letter-like forms, to 1.06 on the criterion, age. For the 1.06 F-ratio, the probability is .39, while for the .19 F-ratio, the probability is .90 . These high probabilities indicate that any differences in the means of the four finger differentiation groups on the criterion measures is a spurious result. There is no statistically significant

TABLE XIII

ANALYSIS OF COVARIANCE ON TEST 1 OF THE
TEST OF FINGER DIFFERENTIATION FOR
NON-ACHIEVING READERS

Criterion	Source	df	MS	Adj. F *	P
Word Knowledge	Group	3	128.11	.73	.54
	Error	25	173.67		
Word Discrimination	Group	3	443.26	.90	.45
	Error	25	490.41		
Reading Comprehension	Group	3	126.43	.91	.45
	Error	25	139.45		
Letter Sequence	Group	3	4.42	.09	.97
	Error	25	51.33		
Letter-Like Forms	Group	3	3.27	.19	.90
	Error	25	17.02		
Age	Group	3	23.02	1.06	.39
	Error	25	21.81		

*Not statistically significant at the .05 level.

difference between the four finger differentiation groups created by Test 1 on the criterion measures; Word Knowledge, Word Discrimination, Reading Comprehension, letter sequence, sequence in letter-like forms, and age.

The four finger differentiation groups created from the performance of the non-achieving readers on Test 2 of the Test of Finger Differentiation were considered next. The F-ratios, adjusted for intelligence, between the means of these four groups on the criterion measures are presented in Table XIV. The probability for each F-ratio is also given.

The F-ratios of the means of the four groups range from a low of .02 on the criterion, age, to a high of .95 on the criterion, letter-like forms. The high probabilities for these F-ratios indicate that any differences which do occur in the means of the four groups on the criterion measures are merely chance occurrences. The lowest probability of .43 for the F-ratio of .95 on the criterion, letter-like forms, is very high. Thus, for the four finger differentiation groups created by Test 2, no statistically significant differences exist between their adjusted mean scores on any of the six criterion measures.

For the four finger differentiation groups created from the performance of non-achieving readers on Test 3 of the Test of Finger Differentiation, the results of analysis were similar to that performed on Test 1 and Test 2. The F-ratios, adjusted for intelligence, between the mean scores

TABLE XIV

ANALYSIS OF COVARIANCE ON TEST 2 OF THE
TEST OF FINGER DIFFERENTIATION FOR
NON-ACHIEVING READERS

Criterion	Source	df	MS	Adj. F*	P
Word Knowledge	Group	3	89.61	.50	.68
	Error	25	178.29		
Word Discrimination	Group	3	305.12	.60	.62
	Error	25	506.99		
Reading Comprehension	Group	3	83.80	.58	.63
	Error	25	144.56		
Letter Sequence	Group	3	16.75	.34	.80
	Error	25	49.85		
Letter-Like Forms	Group	3	14.86	.95	.43
	Error	25	15.63		
Age	Group	3	.58	.02	.99
	Error	25	24.50		

*Not statistically significant at the .05 level.

TABLE XV

ANALYSIS OF COVARIANCE ON TEST 3 OF THE
TEST OF FINGER DIFFERENTIATION FOR
NON-ACHIEVING READERS

Criterion	Source	df	MS	Adj. F*	P
Word Knowledge	Group	3	223.08	1.37	.27
	Error	25	162.27		
Word Discrimination	Group	3	333.07	.66	.58
	Error	25	503.64		
Reading Comprehension	Group	3	243.76	1.94	.15
	Error	25	125.37		
Letter Sequence	Group	3	16.97	.34	.80
	Error	25	49.83		
Letter-Like Forms	Group	3	11.38	.71	.56
	Error	25	16.05		
Age	Group	3	27.28	1.28	.30
	Error	25	21.30		

*Not statistically significant at the .05 level.

of the four groups on each of the criterion measures are presented in Table XV with their probabilities.

The highest F-ratio of 1.94 was obtained between the means of the four groups on Reading Comprehension. It has a P of .15 which places it below the level of statistical significance. The lowest F-ratio of .33 was obtained between the means of the four groups on the Letter-Sequence-in-Words Test. The probability of chance occurrence of this F-ratio, given as .80, is very high.

Again, the F-ratios between the mean scores obtained on each of the six criterion measures, by the four finger differentiation groups from Test 3, cannot be considered statistically significant. There is no difference in the adjusted mean scores of these four groups on any of the six criterion measures.

NON-STATISTICAL ANALYSIS OF DATA

The performance of both groups of readers on the Letter-Sequence-in-Words Test was analyzed by the researcher according to the difficulty experienced with familiar (grade two) words and unfamiliar (grade four) words. An equal proportion of each of these had been maintained in the test. Table XVI presents, for each group, the number of words missed at each grade level and the percentage each was of the total number missed by the group.

TABLE XVI
STUDENT PERFORMANCE ON FAMILIAR AND
UNFAMILIAR WORDS

Group	Total Words Correct	Total Words Missed No.	Grade Two No.	Grade Two Percent	Words Missed	
					No.	Percent
Achieving Readers	819	81	54	66.67	27	33.33
Non-Achieving Readers	670	230	128	55.65	102	44.35

The data on student performance in Table XVI reveal the following information:

(1) The 230 total errors made by the non-achieving readers on letter sequences was almost three times as large as the 81 total errors made by achieving readers. Non-achieving readers experienced much more difficulty than achieving readers in perceiving letter sequences in words.

(2) Both groups of readers made more letter sequence errors on the familiar words than on the unfamiliar words. However, for non-achieving readers, the difference in the percentage of errors occurring with grade two words and grade four words is relatively small. These readers appear to exhibit an indifference towards letter order in both familiar and unfamiliar words - a characteristic which Vernon (1960, p. 28) noted in the reading performance of young children.

(3) The achieving readers made 66.67 percent of their letter sequence errors on familiar words as against 33.33 percent on unfamiliar words. Their errors in the perception of letter sequence was thus twice as great on grade two words as on grade four words. The grade two words were commonly occurring ones in the basal reading material at that level. That these readers could make letter sequence errors with these words and still be achieving well in reading suggests that letter sequence errors pose no problems for them. They do, indeed demonstrate an awareness of letter sequence when they encounter

more difficult words at the grade four level.

SUMMARY OF FINDINGS

The mean scores obtained by the achieving readers on the Letter-Sequence-in-Words Test and the Sequence Test of Letter-Like Forms indicate that they did not experience much difficulty with the visual perceptual tasks involved in either of these tests. The correlation of these results with the results of the three tests of reading achievement revealed that there existed either little relationship or a low negative one, without statistical significance, between these variables for achieving readers.

The mean scores obtained by the non-achieving readers on the Letter-Sequence-in-Words Test and the Sequence Test of Letter-Like Forms indicate that they experienced more difficulty than achieving readers. These mean scores, however, were not low when compared to their mean percentiles on the reading achievement tests. The correlation of these mean scores with reading achievement revealed low positive correlations except for the following:

(a) The correlation between the mean scores on the test of letter sequence and Word Discrimination was significant at the .05 level.

(b) The correlation between the means scores on the test of sequences in letter-like forms and Reading Comprehension was very close to the .01 level of significance.

On the Test of Finger Differentiation, the most

variation in performance was in Test 2, the "in-between test" for both achieving and non-achieving readers. On both of the other tests there was an accumulation of subjects in the P-category. Significantly more subjects were found to have passed Test 3 than Test 2.

An analysis of covariance was performed for the four finger differentiation groups created from the performance of achieving readers on Test 2. The adjusted F-ratios from the means of these four groups on the six criterion measures showed no statistical differences between these groups on any of the six criterion measures.

The performance of non-achieving readers was analyzed on all three tests of finger differentiation. On each one, the means of the four finger differentiation groups on the six criterion measures were adjusted for intelligence. For none of these was the resulting F-ratio statistically significant.

Thus, for both achieving and non-achieving readers, the analysis of covariance on the Test of Finger Differentiation yielded F-ratios which did not reach the level of statistical significance.

An informal analysis of performance on the Letter-Sequence-in-Words Test completed the analysis of the data. This analysis revealed that non-achieving readers made many more letter sequence errors than achieving readers. Also while differences in performance on familiar and unfamiliar words were relatively small for non-achieving

readers, the achieving readers made twice as many errors with familiar words as with unfamiliar words.

CHAPTER V

SUMMARY, CONCLUSIONS, IMPLICATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

SUMMARY

This study was designed to investigate the relationship between the perception of sequence through two sense modalities and the reading achievement of selected grade two children. To investigate this relationship, two questions were posed as the purpose of this study. These questions were:

(1) Are difficulties in the perception of letter sequence and the sequence of letter-like forms experienced by either achieving readers or by non-achieving readers or by both?

(2) Are these same readers experiencing difficulties in the perception of sequence in their body schema as evidenced in their finger differentiation ability?

To investigate these questions a sample of grade two students was selected on the basis of achievement or non-achievement in reading. In the sample selection process, the researcher administered the California Short-Form Test of Mental Maturity - Level 1 and the Metropolitan Reading Achievement Test - Primary II. In addition, the students were given a vision screening on the Keystone Telebinocular.

Those thirty students selected for each group were in the 90-120 range of intelligence and had no serious visual difficulties. Achieving readers were above the seventy-fifth percentile on any two of the three subtests of the Metro-politan Reading Achievement Test. Non-achieving readers were below the forty-fifth percentile on any two of the subtests.

Each of these sixty children were tested, individually, by the researcher on three tests. The Letter-Sequence-in-Words Test (Appendix B) measured the child's perception of letter sequences in words. The Sequence Test of Letter-Like Forms (Appendix C) measured his perception of sequence in letter-like forms (from Gibson, Gibson, Pick and Osser, 1962), after these had been grouped in word-like combinations. The Test of Finger Differentiation (Appendix A) contained three subtests measuring the child's finger differentiation and his awareness of finger sequence or order.

The data were analyzed and interpreted for each group of readers with respect to the four null hypotheses that had been formulated. Partial correlation coefficients, with the effects of intelligence removed, were computed between reading achievement on each of the three subtests and the visual perception of sequence with both letters and letter-like forms. Partial correlation coefficients, again removing the effects of intelligence, were computed between the ability to perceive sequences of letters in words and sequences

in letter-like forms.

An analysis of covariance was used to investigate the relationship of finger differentiation to selected variables. In this analysis, the means of the four groups on each criterion measure, adjusted for the effects of intelligence, were analyzed for statistical differences.

A further analysis of student performance on the Letter-Sequence-in-Words Test was performed to determine whether students were more successful in perceiving letter sequences in familiar or unfamiliar words.

MAIN FINDINGS AND CONCLUSIONS

Hypothesis One

There is no significant correlation between the ability to perceive letter sequences and reading achievement in grade two children, seven to nine years old, when the effects of intelligence are removed, for

(a) achieving readers

(b) non-achieving readers

An analysis of the data supports this hypothesis on all three measures of reading achievement for achieving readers and on two of the measures for non-achieving readers. The hypothesis is rejected for non-achieving readers on one measure of reading achievement, Word Discrimination.

No relationship was found to exist between the

ability of the achieving reader to perceive letter sequences in words and his reading achievement. An analysis of student performance on the Letter-Sequence-in-Words Test relates to the findings of this hypothesis.

The performance of the achieving grade two reader on this test would suggest that his perception of letter sequences in words is not affecting his reading success and his use of letter sequences appears governed by the expediency of the situation. He tends to use this ability when he encounters an unfamiliar situation. This behaviour resembles that described by Vernon (1962, p. 110) as forming part of the reading performance of the literate adult. This may mean that the achieving reader, at the end of Grade Two, has already assumed some of the characteristics of the mature reader.

The perception of letter sequences in words had more relationship to the reading achievement of the non-achieving readers. An analysis of their performance on the Letter-Sequence-in-Words Test revealed that they did experience difficulty with this task. However, the relationship between this and their reading achievement is low enough to suggest that the perception of letter sequence is not a strong factor in their reading difficulties. It may be that these readers exhibit an indifference to letter order as a result of their reading failure.

The results of this hypothesis tend to agree with those of Sterritt, Martin and Rudnick (1969) who found the relationship between their tests of sequential pattern

perception and reading achievement to be low. They found that sequence perception through the visual-spatial modality--the modality used to test this hypothesis--tended to be the easiest task.

It may be that sequence as measured in this study, with a matching-type exercise using only the visual-spatial modality, did not resemble closely enough the reading situation to determine the actual relationship.

Hypothesis Two

There is no significant correlation between the ability to perceive sequence in letter-like forms and reading achievement in grade two children, seven to nine years old, when the effects of intelligence are removed, for

(a) achieving readers

(b) non-achieving readers

Again, the analysis of the data supports this hypothesis on all three measures of reading achievement for achieving readers and on two of the three measures for non-achieving readers. The hypothesis is rejected for non-achieving readers on one measure of reading achievement, Reading Comprehension. The rationale behind choosing to use letter-like forms as well as actual letters arose out of the issue of symbol versus form in measuring visual perceptual abilities in reading. Because of the doubt surrounding the use of geometric forms and configurations, this study used the twelve letter-like forms derived from an analysis of the

basic differences in alphabetic letters. In this way, sequence perception of both meaningful and meaningless material was correlated with reading achievement.

From the analysis performed, it can be concluded that there is little difference in the relationship between reading achievement and the perception of sequence using either alphabetic letters or letter-like forms for achieving readers. A similar conclusion can be reached for non-achieving readers, although the one significant relationship occurring with each measure of sequence involved a different aspect of reading achievement.

These same letter-like forms had been used by Netzer (1969) in her study of sequence discrimination. The results obtained in the present study appear to conflict with those she obtained. She found the difference in the performance of good and poor readers in discriminating three-figure sequences to be significant and significantly related to their reading scores. In the present study, there was less than a two-point difference in the mean scores of the two groups in discriminating sequences in these letter-like forms.

In comparing the results of these two studies, the differences in the two samples must be considered. Netzer conducted her research on children at the beginning reading stage while this study used children at the end of Grade Two. The awareness of sequence of these two groups of subjects may be very different both because of the maturational factor (Piaget, 1967; Vernon, 1962) and the

experiential factor (Gottschalk, Bryden and Rabinovitch, 1964).

It may be that the perception of sequence in letter-like forms is significant in the reading performance of the beginning reader and significantly related to his reading ability, while, at a more advanced level, other factors become significantly more important and the perception of sequence is no longer a controlling variable for achieving readers. For the non-achieving reader, who has not advanced as far beyond the beginning reading stage, some relationship would continue to exist.

Hypothesis Three

There is no significant correlation between the ability to perceive letter sequences in words and the ability to perceive sequence in letter-like forms, when the effects of intelligence are removed, for

- (a) achieving readers
- (b) non-achieving readers

An analysis of the data supports this hypothesis for achieving readers and rejects it for non-achieving readers.

There was practically no relationship between the ability of the achieving reader to perceive letter sequences in words and his ability to perceive sequences in letter-like forms.

There was a strong relationship between the ability of the non-achieving reader to perceive letter sequences in

words and his ability to perceive sequences in letter-like forms.

For the non-achieving readers, this finding would suggest that his perception of sequence in one of these mediums can be used a predictor of his achievement in the other.

Hypothesis Four

Within each of these groups of readers, there is no significant difference among the finger differentiation groups, controlling for intelligence, on

- (a) Reading Test 1 - Word Knowledge
- (b) Reading Test 2 - Word Discrimination
- (c) Reading Test 3 - Reading Comprehension
- (d) Letter-Sequence-in-Words Test
- (e) Sequence Test of Letter-Like Forms
- (f) Age

An analysis of the data supports the acceptance of this hypothesis. The four finger differentiation groups as they had been created for this study did not differ significantly in their performance on any of these criterion measures.

For the achieving readers, such a large accumulation of subjects placed in the P-category on Test 1 and Test 3 of the Test of Finger Differentiation that there was not enough variation in the categories for a statistical analysis to be performed. However, Test 2 yielded more variation in

performance. When analyzed, it revealed that the reading achievement, the sequence perception, and the age of achieving readers did not bear any relationship to their performance in finger differentiation.

For non-achieving readers, an analysis was performed using all three tests. The findings again revealed that their finger differentiation ability bore no relationship to their reading achievement, their sequence perception, or their age.

IMPLICATIONS

This study revealed that letter-sequence errors do not have an effect on the reading performance of achieving readers as investigated in this study. While the total number of errors that they make is relatively small, a higher proportion of these errors occur with familiar words than unfamiliar ones. It would appear that such errors occurring in the classroom work of achieving readers should not be unduly emphasized or taken as an indication that they do not know the words in which these errors occur. It appears that factors other than the visual-spatial perception of sequence, as investigated here, have become controlling variables in the reading success of these achieving readers.

Non-achieving readers tended to make many more letter sequence errors than achieving readers. This had a significant relationship to one aspect of their reading achievement, word discrimination. The non-achieving reader may thus be able to improve his word discrimination ability by improving

his perception of letter sequences in words. In the major proportion of words used to test this ability in the present study, internal changes had been made in the letter sequences. It may thus be that these readers need training in perceiving the internal details of words.

These non-achieving readers may also require specific training in discriminating which letter sequences are likely ones to occur in the English language. The wide variation in performance which was noted among these readers in word discrimination would suggest that some non-achieving readers require a training program in relating the sound sequences which they hear to the letter sequences on the printed page.

However, not all the non-achieving readers in this study were deficient in this ability, while some achieving readers were. It appears as an individual characteristic of the student which, for some readers, combines with a multiplicity of factors to culminate in reading difficulty. It will thus be necessary to assess the individual needs of the learner for a training program in relating sound sequences to printed letter sequences.

The strong relationship which exists, for the non-achieving reader, between his perception of sequence in letter-like forms and his perception of letter sequences in words suggests that sequence training with letter-like forms may be used to develop his perception of sequence. The non-achieving reader, because of his failure in the reading situation, may have developed an aversion to letters and

words which would hinder the progress of a corrective program. The development of his perception of letter sequences, if it forms part of this corrective program, can be facilitated through the medium of letter-like forms which carry no unpleasant connotations for him.

The finger differentiation ability which formed part of this study had originally been identified through clinical work with special disability cases. It had also been identified as a developmental factor in the young child. In this study, it was found that not all the subjects had this finger differentiation ability. However, that revealed no statistical relationship to the performance of the subjects on the criteria measured. It may be entirely possible that, even if finger differentiation is developmental, it does not affect the normal functioning of average children. Its effect on reading performance may be much more specialized and limited to reading disability cases. It may also be that, by itself, the effects of this ability are not significant, whereas, when it is one of several contributing factors, it combines with these to exert a significant influence on reading achievement. As an area of study, more information may be obtained about its possible effect on reading performance through studying clinical reading cases.

SUGGESTIONS FOR FURTHER RESEARCH

The following problems arise out of this study as areas for further research:

(1) This study revealed that the non-achieving reader made many letter sequence errors. The relationship of this to his reading achievement might be further assessed by determining his recognition ability on the words on which he makes these letter sequence errors as well as the effect of training in the perception of letter sequence on his word recognition ability.

(2) This study centered on sequence perception through the visual-spatial modality only. Reading in the primary grades, however, also involves a large auditory factor. The study of sequence perception in the field of reading can be furthered by an investigation of auditory-temporal sequential perception as it relates to reading achievement.

(3) Drawing from both the visual and auditory fields, the question of the role of sequence perception in reading could also be investigated by a study on modality transference of a sequence, as from an auditory-temporal sequence to a visual-spatial sequence, as it relates to reading achievement. Transference from the auditory modality to the visual and from the visual to the auditory forms a constant part of primary reading.

(4) Differences between the results obtained with letter-like forms by this study and by Netzer's study (1969) were partly attributed to the sample differences. Drawing on these two studies, another might be designed to investigate visual spatial sequence perception on a developmental

basis in the reading achievement of primary children.

(5) In the present study, finger differentiation ability was studied in children at a specific age level. The mean age of these children was beyond the highest age level tested by Kinsbourne and Warrington (1963), yet the percentage of successes achieved in this study was not as high as those they give for their oldest age group. It may be that the different results obtained are related to cultural differences in the early education of Canadian and British children. A study of Canadian children, designed to replicate that of Kinsbourne and Warrington (1963), could determine whether they exhibit a developmental pattern similar to that found in British children. As well, such a study could focus on the emphasis in both cultures on early childhood education as it might affect this developmental ability.

(6) In examining the possibility that difficulties in finger differentiation are related to difficulties in sequence perception and reading achievement, a study might be centered on reading disability cases such as those treated at a reading clinic. This would provide a more specialized population for study.

CONCLUDING STATEMENT

The suggestion had been made by researchers (Kinsbourne and Warrington, 1963) investigating finger differentiation that this ability might be related to the

aquisition of other abilities by the child where the spatio-temporal perception of sequence is required. Because this perception of sequence is required in the reading situation, these two abilities were isolated for study in the reading context.

Two groups of readers who are normally found in a classroom were selected as subjects in the investigation. By contrasting the performance of non-achieving readers with achieving readers, it was hoped to determine whether these factors were contributory ones to the reading difficulties of non-achieving readers.

While the visual-spatial perception of sequence was found to have some relationship to the reading achievement of non-achievers and not to the reading achievement of achievers, this did not appear as a particularly strong relationship. The relationship of finger differentiation to the selected variables was not significant for either group of readers.

However, there were differences noted in the performance of both groups in both sequence perception and finger differentiation. It is possible that further investigation of these differences can lead to increased understanding of some of the factors involved in the difficulties experienced by non-achieving readers.

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APPENDIX A

TEST OF FINGER DIFFERENTIATION

TEST OF FINGER DIFFERENTIATION

1. Finger Differentiation Test

The subject faces the examiner, hand palm down, fingers spread, eyes closed. Two points on the fingers are simultaneously touched - some times both on the same finger and sometimes on two adjacent fingers. The examiner asks: "How many fingers am I touching - one or two?" He maintains contact until an answer is given, and long enough after this to permit the subject to verify the answer under direct vision. The procedure is repeated eight times, four on each hand. Simultaneous touch is applied to the same finger and to two adjacent fingers in irregular sequence. Two trials involving the same finger were given with each hand, and two involving adjacent fingers.

The test is preceded by an illustrated explanation under vision - "now I am touching one finger - now I am touching how many finger?"

The examiner does not embark on the test proper until he has ascertained that the subject understands what is required.

Six correct answers out of eight are accepted as a "pass".

2. The "In Between" Test

With the hand positioned as before, two fingers are simultaneously touched. The examiner asks: "How many fingers are there in between the ones I am touching - how many in

the middle?" He then maintains contact until answered, and long enough to permit the subject to verify the answer under direct vision.

The test is repeated eight times, four on each hand. The finger pairs are touched in irregular sequence, but such that the correct answer on each side should once be "0", twice "1", and once "2".

The test is preceded by an illustrated explanation while the subject has his eyes open. "Now there are two in the middle - now there aren't any - now there are how many?" The test proper is only begun when the task has been well understood.

Six correct answers out of eight satisfy the requirements for "pass".

3. Finger Block Test

Four wooden blocks are placed on the table. While his eyes are closed, the subject's fingers are moulded around one of four corresponding test blocks. He is then asked to open his eyes, and without looking at the block in his hand, to pick out the corresponding one on the table: "Which of these is the same as the one in your hand?" Having answered, he is permitted to verify his answer by direct visual comparison. This test is preceded by an illustrated demonstration under vision. "This block is the same shape as that one, this block is the same as which one?" When the examiner is satisfied that the test is understood, he proceeds to the test proper.

Each hand is used in four trials; each of the four blocks is used twice, one in each hand. Six correct answers out of eight are considered a "pass".

Subject's Name : _____

Sex : _____

Birthdate : _____

Age : _____

Preferred Hand : _____

1. Finger Differentiation TestRight hand

one finger : (a.) _____

(b.) _____

two fingers : (a.) _____

(b.) _____

Left hand

one finger : (a.) _____

(b.) _____

two fingers : (a.) _____

(b.) _____

2. In-between TestRight hand

(a.) _____

(b.) _____

(c.) _____

(d.) _____

Left hand

(a.) _____

(b.) _____

(c.) _____

(d.) _____

The Finger Block TestRight hand

(a.) _____

(b.) _____

(c.) _____

(d.) _____

Left hand

(a.) _____

(b.) _____

(c.) _____

(d.) _____

COMMENTS

APPENDIX B

LETTER-SEQUENCE-IN-WORDS TEST

neighbour	neighbour	neighbour	nieghbour	neighbuor
people	poepel	peolpe	peopel	people
nuisance	niusance	nusiance	nuisance	unisance
mean	mean	maen	naem	neam
breakfast	breakfsat	breafkast	breakfast	braekfast
frontier	frontier	forntier	fronteir	frnotier
gaped	gsaped	pasged	gaped	gapsed
chimney	chminey	chimeny	chinmey	chimney
meow	moew	woem	meow	weom
frequent	ferquent	frequent	frequenet	freqeunt
cygnet	cgynet	cygent	cygnet	cynget
echo	ceho	ohce	ehco	echo
scenery	scenrey	scneery	secnery	scenery
pumpkin	pmupkin	punpkim	pumpkin	pumkpin
scramble	scrmable	scramble	srcamble	csramble

curious	cruious	curiosu	curious	curoius
pencil	pecnil	pnecil	penicl	pencil
surfeit	surfeit	surfiet	srufeit	surefit
dignity	dingity	digntiy	diginty	dignity
picture	pitcure	pictrue	pciture	picture
grocery	groecry	grocery	gorcery	grocrey
traffic	traiffc	tarffic	traffic	trafifc
hideous	hideos	hidoeus	hideuos	hiedous
waved	waevd	devaw	waved	wvaed
lariat	lairat	lariat	larait	tairal
hangar	hangar	hargan	hagnar	hnagar
turtle	turlte	turtle	trutle	turtel
desperate	dseperate	desperate	depserate	despearte
scared	scaerd	sacred	scraed	scared
policeman	policmean	poliecman	policeman	poilceman

APPENDIX C

SEQUENCE TEST OF LETTER-LIKE FORMS.

[illegible]

APPENDIX D

CORRELATIONS BETWEEN INTELLIGENCE AND SCORES
ON SEQUENCE TESTS

CORRELATION BETWEEN INTELLIGENCE AND SCORES
ON THE SEQUENCE TESTS

<u>LETTER-SEQUENCE-IN-WORDS TEST</u>		<u>SEQUENCE TEST OF LETTER-LIKE FORMS</u>	
Achieving Readers	Non-Achieving Readers	Achieving Readers	Non-Achieving Readers
<hr/>			
Intelligence			
-.22	.11	.13	-.05
<hr/>			

B29950